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RESEARCH REPORT

THE ROLE OF BIRTH ORDER IN INFANT MORTALITY IN IFAKARA DSS AREA IN RURAL TANZANIA

BY

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RESEARCH REPORT SUBMITTED TO THE FACULTY OF HEALTH SCIENCES, UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG, IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER OF SCIENCE IN MEDICINE IN THE FIELD OF POPULATION-BASED FIELD EPIDEMIOLOGY.

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Declaration

I, Matthew Dery Sangber-Dery, declare that this research report is my own work. It is being submitted for the degree of Master of Science in Medicine in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other university.

30th October, 2009

Dedication

This piece of work is dedicated to our Heavenly Father who guided me, especially in times of sickness, to finally see me through. May His Name be praised!

I also dedicate this work to my nephews Cornelius Sangber-Dery and Paschal Dery who rushed me to the 37 Military Hospital, Accra when I collapsed on 25th January 2008, the day of my departure to South Africa for this Course.

Finally to my mother Bibiana Dongdem Dery who did not live to see this achievement. May her departed soul rest in perfect peace.

Abstract

Introduction: Studies of factors affecting infant mortality have rarely considered the role of birth order. Despite the recent gains in child mortality in Tanzania, infant mortality rate is still high (68 per 1000 live births) according to the Tanzania Demographic Health Survey (2004-5). This study investigated the risk factors associated with infant mortality in Ifakara Health and Demographic Surveillance Systems area in rural Tanzania from January 2005 to December 2007 with specific reference to birth order, and identified causes of infant death for the study period.

Materials and Methods: The study was a secondary analysis of existing data from the Ifakara Health and Demographic Surveillance Systems (HDSS). Child data for 8916 live births born from 1st January 2005 to 31st December 2007 were extracted for analysis. The binary outcome variable was infant mortality. Tables and graphs were used to describe the distribution of maternal demographic and study population characteristics. Poisson regression analyses were used to establish the association between infant mortality and exposure variables.

Results: We recorded 562 infant deaths. Neonatal mortality rate was 38 per 1000 person-years while infant mortality rate was 70 per 1000 person-years. Birth order of 2nd to 5th was associated significantly with 22% reduced risk of infant mortality (IRR=0.78, 95%CI: 0.64, 0.96; p=0.02**)** compared with first births. The infant mortality rates per 1000 person-years for first births was 84, 2nd to 5th was 66 and sixth and higher was 71 per 1000 person-years.

Male infants were 17% more at risk of infant deaths as compared to their female counterparts, but not statistically significant (IRR=1.17, 95%CI: 0.99, 1.38; p=0.06). Mothers aged 20 to 34 years had 19% reduced risk of infant death (IRR=0.81, 95%CI: 0.65, 1.00; p=0.05) as compared to mother of less than 20 years of age. Singleton births had 71% reduced risk of infant mortality (IRR=0.29, 95%CI: 0.22, 0.37; p<0.001**)** compared with twin births. Mothers who did not attend antenatal care had 2% reduced risk of infant deaths (IRR=0.98, 95%CI: 0.49, 1.97) but not statistically significant compared with mothers who attended antenatal care. Mothers who delivered at home were 1.05 times more at risk of infant deaths but not statistically significant (IRR=1.05, 95%CI: 0.89, 1.24; p=0.56). Mothers who had no formal education were 1.41 times more likely to have infant deaths (IRR=1.41, 95%CI: 0.72, 2.79; p=0.32) as compared to those who had education beyond primary. When adjusted for sex, maternal age and twin births, second to fifth birth order had 20% reduced risk of infant death (IRR=0.80, 95%CI: 0.61, 1.03; p=0.08), but statistically not significant as compared to first births. Malaria (30%), Birth injury/asphyxia (16%), Pneumonia (10%), Premature and/or low birth weight (8%), Anaemia (3%) and Diarrhoeal diseases (2%) were the major causes of infant deaths from 2005 to 2007.

Discussion and conclusion: First births and higher birth orders were associated with higher infant mortality. Twin birth was a risk factor for infant mortality. The health systems should be strengthened in providing care for mothers and child survival. We recommend that the high-risk group, first or sixth or higher pregnancies, need special care and the existing health management system may be strengthened to create awareness among potential mothers for seeking appropriate health care from the beginning of pregnancy. Also, antenatal care follow-up can be emphasized for high-risk mothers. Efforts to control mosquitoes must be accelerated in the Ifakara sub-district.

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To the Director of Kintampo Health Research Centre, Ghana, Dr Seth Owusu-Agyei, I say I am very much grateful to you for your recommendation for me to undertake this prestigious course at the University of the Witwatersrand, South Africa. May God richly bless you.

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Definition of terminologies

Neonatal mortality rate: This refers to the number of deaths in infants less than 28 days of age per 1000 live births.

Early neonatal mortality rate: This refers to the number of live born infants who die in the first week per 1000 live born infants.

Infant mortality rate: This refers to the number of deaths in children less than one year old per 1000 live births usually expressed as the probability of dying before first birthday per 1000 live births.

Under-five mortality rate: This refers to the number of deaths in children less than five years old per 1000 live births usually expressed as the probability of dying before fifth birthday per 1000 live births.

Preterm delivery: Births at less than 37 completed weeks of gestation per 100 live births.

Wealth Index: This is a proxy measure of the wealth of households which based on household characteristics, ownership of assets (house ownership, animal ownership, etc)

Birth order: This is defined as the birth positions of a live birth to a specific woman in relation to her other births.

Verbal Autopsy: This is a method that uses a standardised questionnaire to find out the cause of a death of a person based on an interview with next of kin or other caregivers.

List of acronyms

MDG Millennium Development Goals

HIV Human Immunodeficiency Virus

AIDS Acquired Immunodeficiency Syndrome

WHO World Health Organization

UNDP United Nations Population Division

UNICEF United Nations Children's Fund

IHI Ifakara Health Institute

IHDSS Ifakara Health and Demographic Surveillance System

DSA Demographic Surveillance Area

TDHS Tanzania Demographic and Health Survey

IMR Infant Mortality Rate

NMR Neonatal Mortality Rate

PNMR Post-Neonatal Mortality Rate

INDEPTH International Network for Continuous Demographic Evaluation of Populations and Their impact on Health in Developing Countries

HRS Household Registration System

PYO Person Year of observation

TBA Traditional Birth Attendant

VHWs Village Health Workers

VA Verbal Autopsy

PCA Principal Component Analysis

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CHAPTER ONE: INTRODUCTION AND LITERATURE REVIEW

1.1 BACKGROUND

The Millennium Development Goal four (MDG-4) calls for a reduction in child mortality by two-third between 1990 and 2015. In 2006, close to 9.7 million children died before their fifth birthday, with most of the deaths occurring in developing countries (1). Furthermore, available reports also indicate that, about 3.3 million babies are still born, and that more than 4 million infants die within the first 28 days of life, and that a further 6.6 million young children die before their fifth birthday (2).

Most under-five deaths have been attributed to diarrhoea, acute respiratory infections (ARI), malaria, measles, malnutrition, and HIV/AIDS - conditions that are either preventable or treatable with low-cost interventions. Studies have further shown that under-five mortality rates could be reduced by about 25 to 30 per cent if all young children in malarial areas were protected by treated bed nets at night (3). The highest mortality rates worldwide are still in sub-Saharan Africa, where approximately 15% of newborn children are expected to die before reaching their fifth birthday (4).

Every year an estimated 4 million babies die in the first 4 weeks of life (the neonatal period). A similar number are stillborn, and 0·5 million mothers die from pregnancy-related causes. Three-quarters of neonatal deaths happen in the first week-the highest risk of death is on the first day of life. Almost all (99%) neonatal deaths arise in low-income and middle-income countries (5).

An analysis controlling for frailty effects in a study on determinants of infant and child mortality in Kenya showed that 70 per 1,000 children had died by age one, 85 per 1,000 had died by age two, while 104 per 1,000 children had died by age five (6). In Tanzania, according to the World Health Organization (WHO) Health Statistics report issued in 2008, under-five mortality rate was 118 per 1000 live births, infant mortality rate was 74 per 1000 live births and neonatal mortality rate was 35 per 1000 live births in 2004 (7). Also most child deaths are reportedly due to malaria, pneumonia, malnutrition and complications of low birth weight as well as HIV/AIDS. Malnutrition is also considered to be an underlying factor in more than 50 per cent of child deaths while neonatal deaths account for 48 per cent of infant mortality

1.2 PROBLEM STATEMENT

In developing countries, one child in 12 dies before its fifth birthday, compared with 1 in 152 in high-income countries. Child deaths have dropped rapidly in the past 25 years, but progress everywhere slowed in the 1990s, and a few countries have experienced increases in the same period. At current rates of progress, only a few countries are likely to achieve the Millennium Development Goal of reducing child mortality to one-third of their 1990 levels (8).

Short birth intervals, teenage pregnancies and previous child deaths are found to be associated with an increased risk of death in children under-five in Tanzania (9). However, the most recent literature on the effect of birth order on infant mortality in rural Tanzania at a district level which is needed to inform policy makers is generally lacking. This study therefore aims to contribute to filling this research gap.

1.3 JUSTIFICATION FOR STUDY

In Tanzania vital registration has a low coverage particularly in rural setting. Mortality estimates are mainly derived from the censuses and Demographic and Health Surveys (DHS). Each of these sources has limitations; estimates from census for example use models that work on critical assumptions such as fertility remaining constant for sometime. Health and demographic surveillance is a response to the lack of a valid information base that can provide high quality longitudinal data on population dynamics, health and social change to inform policy and practice. Although information on birth outcomes are important to plan maternal and child health care services, accurate indices especially from developing countries are quite difficult to obtain. Furthermore, community based information on infant mortality and birth order in Tanzania is solely available from the DHS. Although progress towards achievement of the Millennium Development Goal for child mortality at national level can be assessed using the DHS data, district-level assessment needs community-based data from other sources. Such data can also contribute into understanding of maternal and other risk factors of infant deaths that are important for proper planning and development of interventions. The IHDSS provides reliable longitudinal population-based health and demographic information. Studies have also shown risk factors for infant mortality but rarely look at birth order. This study therefore aims to contribute to the limited knowledge on the effect of birth order on infant mortality from a rural perspective and contribute to the realization of the Millennium Development Goal on the reduction of child mortality.

1.4 LITERATURE REVIEW

1.4.1 CAUSES OF INFANT MORTALITY

The main causes of under-five mortality are diarrhoea, acute respiratory infections (ARI), measles, malaria and HIV/AIDS (3). It was found that out of about 10.6 million yearly deaths in children younger than age 5 years between 2000 and 2003, six main causes accounted for 73%; notably pneumonia (19%), diarrhoea (18%), malaria (8%), neonatal pneumonia or sepsis (10%), preterm delivery (10%), and asphyxia at birth (8%). Undernutrition is an underlying cause of 53% of all deaths in children younger than age 5 years (10). Between ages 1-5 years the common causes of mortality remain infectious and parasitic diseases (11).

In a two-year prospective birth cohort study in a rural Kenyan District Hospital to estimate cause-specific mortality and severe morbidity in infants too young to gain benefit from routine immunization approaches, out of a total of 2,359 infants 136 (6%) were stillborn and 77 (3.5%) subsequently died. Prematurity (34%), birth asphyxia (27%), and infection (18.5%) were the predominant causes of death in the first 98 days of life, although infection accounted for 36% of all life-threatening illness episodes in the same period (1999-2001) (12).

1.4.2 MATERNAL CHARACTERISTICS AND INFANT MORTALITY

In an attempt to identify socioeconomic and demographic factors that influence infant and child mortality in Kilimanjaro, Tanzania and also to examine the extent to which socioeconomic factors operate through proximate determinants to bring the influence on infant and child mortality, a study found that maternal demographic status (an index of age and parity), breast-feeding duration, and birth interval had a statistically significant effect on infant and child mortality. Maternal education and occupation showed no significant association with infant and child mortality (13).

In a further study in Tanzania, socioeconomic variables were found to be significantly associated with child mortality even after controlling for intervening and proximate factors (14). The risk of child mortality was 1.3 times higher for children of mothers with no primary education as compared to those with formal education. However, proximate determinants decreased the effects of education. Child mortality risk was about 1.6 times higher for children of employed mothers. (14).

In rural Nepal, a study to assess the effect of previous child death on infant and child mortality showed that among children of mothers whose older child survived, the risk of death during infancy for the index child was 3 times higher in short birth interval (18 months) than in long birth intervals (36+ months); but among the children of mothers whose older child died, the risk of infant death for the index child was only about twice as high (15). This may be due to the fact that when the previous child dies, there is no competition; the short birth interval does not represent an additional risk, presumably because the competing child effect is removed. However, at inter-birth intervals (categorized as 18-23 months, 24-35 months, and 3 years or more), the death of the older sibling increases the risk to the index child (family environment effect) (15). Studies have also demonstrated a strong relationship between a mother’s pattern of fertility and her children’s survival chances. Typically, infants and young children have a higher risk of dying if they are born to very young mothers or older mothers, if they are born after a short birth interval, or if their mothers have already had many children (16).

Teenage mothers and those over 34 years of age ran nearly twice the risk of having an unfavourable outcome of pregnancy compared with mothers aged 20-29 years. Maternal illiteracy was found to be associated with significantly higher risk of neonatal mortality with the rate decreasing with increasing years of education(17). In Kenya, under-5 mortality increased substantially (ranging from 25% to 71% in 10 years) among children born to less educated mothers (test for difference between educational groups: P = 0.074) and in rural areas (P = 0.090) (18).

A study on health and survival of young children in southern Tanzania found infant mortality to be 76.4 per 1000 live births. This was 40% higher for teenage mothers than older women (RR 1.4, 95% CI: 1.1 - 1.7), and 20% higher for mothers with no formal education than those who had been to school (RR 1.2, CI: 1.0 - 1.4) (19).

Maternal anaemia in pregnancy has been shown to have an impact on infant mortality. After controlling for other factors in a study to assess anaemia in pregnancy and infant mortality in Tanzania, the hazards ratio for infant mortality amongst women who had been severely anaemic in pregnancy (Hb < 8 g/dl) was 3.1 [95% CI: 1.1–9.1, p=0.04] compared with women with Hb above 8 g/dl (20). Studies have also shown that infants of smoking mothers have a higher mortality rate, are smaller, experience learning deficits, and potentially have a higher incidence of behavioural problems (21). Early motherhood is often a death sentence for the mother and her baby. Both are at risk of dying as a result of complications during pregnancy and child birth. According to the Save the Children's 2004 report on State of the World's Mothers, lack of education is among the causes of early pregnancies and uneducated mothers are at a severe disadvantage, as are their babies. The report states that, mothers who missed out on schooling are more likely to be poor, to get pregnant younger and more often, to have higher rates of newborn and maternal mortality, to be less knowledgeable about family planning and HIV prevention, and to be less prepared to look after the health and well-being of their babies (22).

1.4.3 BIRTH ORDER AND INFANT MORTALITY

In a study to determine the impact of maternal and child health (MCH) services on child survival in a socio-economically poor rural Pondicherry, India, infants of birth order 1 or more than 4 had higher mortality rates. Birth order 2 infants had the least mortality (23).

A study conducted in Taiwan showed that mothers aged 19 years or less, those giving birth to either their first children or to their fifth or later child, and those who had their first prenatal care visit after the first three months of pregnancy were associated with increased risk of early neonatal deaths (24).

In Yemen, the infant mortality rate was 110 deaths per 1,000 live births for first births, and decreased to 76 deaths per 1,000 live births for fourth to sixth order births, then increases for birth order 7 or higher (25).

In a study to assess risk factors for infant mortality in a rural community in Nigeria, first birth order and older mothers (>34 years) at time of infant death were found to be associated with significantly higher risk for mortality($p=0.004$) (26). Another study also showed that higher order births (more than 5), births to young women (under 20 years of age), and births to older women (more than 34 years of age) increased the risk of dying at infancy (27).

A spatial analysis was carried out to identify factors related to geographic differences in infant mortality risk in Mali. The study linked data from two spatially structured databases: the Demographic and Health Surveys of 1995-1996 and the Mapping Malaria Risk in Africa database. Mother's education, birth order and interval, infant's sex, residence, and mother's age at infant's birth were found to have a strong impact on infant mortality risk (28).

1.5 RESEARCH QUESTION

Is birth order associated with infant mortality in Ifakara in rural Tanzania from 2005 to 2007?

1.6 OBJECTIVES

1.6.1 GENERAL OBJECTIVE

- To determine the risk factors associated with infant mortality in Ifakara in rural Tanzania from January 2005 to December 2007

1.6.2 SPECIFIC OBJECTIVES

- To describe infant mortality by birth order.
- To examine the association between birth order and infant mortality.
- To identify other risk factors associated with infant mortality.
- To describe the causes of infant deaths from 2005 to 2007.

CHAPTER TWO: METHODOLOGY

2.1 INFORMATION ABOUT THE STUDY AREA

This study was carried out in the population covered by the Ifakara Health and Demographic Surveillance Systems (IHDSS) in rural Tanzania. The IHDSS extends latitudes 8°00'–8°35'S and longitudes 35°58'–36°48'E, with altitude 270–1000 m above sea level and includes 25 villages of Kilombero and Ulanga districts, in the Morogoro region of southwest Tanzania, about 320 km from Dar es Salaam . The area covers 80 km ×18 km in Kilombero District and 40 km ×25 km in Ulanga District, making a total of 2400 km^2 of Guinea savannah in the floodplain of the Kilombero River, which divides the two districts. The Udzungwa Mountains lie to the northwest. The area has a rainy season from November to May, but rain may fall in any month of the year. Annual rainfall is 1200–1800 mm, and the annual mean temperature is 26°C (29)

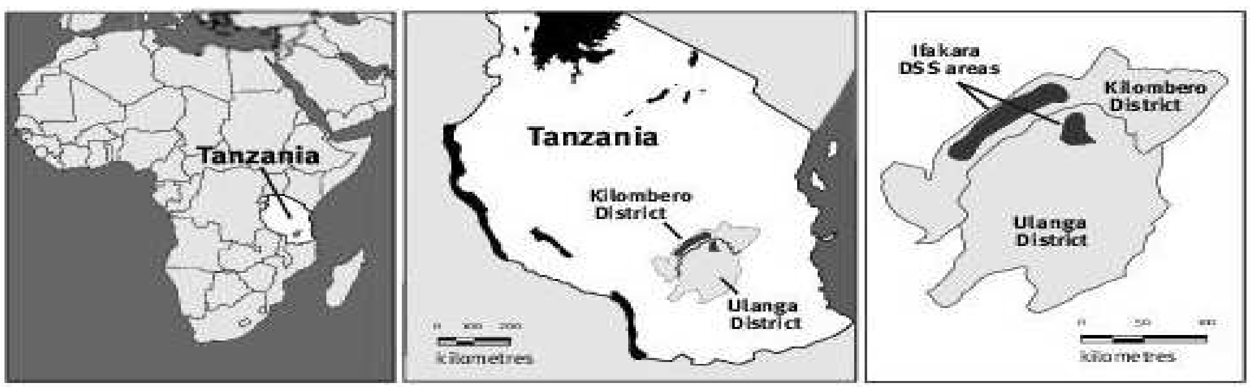

Figure 1: Location of the Ifakara DSS site, Tanzania (monitored population, 60 000)

The total fertility is estimated at 4.8 births per woman. During 2007 the infant mortality rate was 66 per 1000 live births, and mortality in children 1–4 years old was 10.4 per 1000 person years per year. Average household size is 5.0, and 81% of all households are male-headed. The population is highly mobile, with most families moving to the *shamba* areas for a few weeks at a time, depending on the farming season (29).

2.2 PRIMARY DATA SOURCE

The Ifakara Health and Demographic Surveillance site (DSS) datasets are the primary data source. Child and maternal data were extracted for the purpose of this study. The HDSS employed a non-randomised, purposive technique in selecting the areas under surveillance. The HDSS approach involved a continuous monitoring of households and members within households in cycles or intervals, known by HDSS as 'rounds' of four months each. The Ifakara HDSS conducted the initial census of the residents in the selected villages from September to December 1996. For each individual a unique identification is assigned along with the name; date of birth, sex and relationship to the head of household. Since January 2007, each registered household has been visited by a trained interviewer once in every four months to update the household registers by recording births, deaths, in and out migrations as well as pregnancies. Each event is recorded in a specific form that is entered into the computer to update the database accordingly. Education and household economic status data is collected once annually. Members (or residents) of the HDSS are individuals who have resided in the survey area for a period of the previous four months.

2.3 VERBAL AUTOPSY.

Knowledge about the distribution of causes of death in populations is essential for public health planning, resource allocation and measuring the impact of interventions. However, particularly in high mortality settings, vital registration data are often missing, incomplete or inaccurate (30). In such settings verbal autopsy methods have been applied. A verbal autopsy is a method of finding out the cause of a death based on an interview with next of kin or other caregivers. In order for verbal autopsies to be comparable, they need to be based on similar interviews, and the cause of death needs to be arrived at in the same way in all cases. Verbal autopsies have been used more widely to provide information on cause of death in areas where civil registration and death certification systems are weak, and where most people die at home without having had contact with the health system (31).

Verbal autopsy is conducted on all deaths registered in the Ifakara HDSS by trained interviewers using specific standard questionnaires which are used to determine cause of death. The questionnaire (verbal autopsy tool) includes identification information, open ended and closed questions on history of events leading to death, signs and symptoms of the terminal illness, reported medical care and (if available) information from medical records. Completed questionnaires are coded independently by two physicians according to a list of causes of death based upon the tenth revision of the International Classification of Diseases. A third physician independently codes the VA in case of discordant results from the first two physicians. Where there are three discordant codes, the cause of death is recorded as "undetermined".

Given the lack of reliable vital statistics, the options for estimating mortality burden are extremely limited in resource constrained settings. They include: household surveys for estimates of total child and, occasionally, maternal mortality; facility-based death statistics from routine health management information systems; community-based mortality statistics derived from the application of verbal autopsy (VA) in demographic surveillance systems (DSS) and sentinel/sample vital registration (SVR) systems (32). It is an important method for deriving cause-specific mortality estimates where disease burdens are greatest and routine cause-specific mortality data do not exist. Verbal autopsy also reliably estimate Cause-Specific Mortality Fractions (CSMFs) for diseases of public health importance in all age groups in Tanzania (33).

2.3 STUDY DESIGN

The study was a prospective cohort study (where each child was observed from the time of birth to one year) involving secondary data analysis of the Ifakara Health and Demographic Surveillance System (IHDSS) dataset for children who were born between 1st January 2005 and 31st December 2007.

2.4 STUDY POPULATION

All children who were born alive in the Ifakara Health and Demographic Surveillance area.

2.5 SAMPLING AND STUDY SAMPLE

The IHDSS area was selected using a non-randomised, purposive sampling technique. This study selected all children who were born alive in the period 1st January 2005 to 31st December 2007.

2.5.1 INCLUSION CRITERIA

All children born alive in the period 1st January, 2005 to 31st December, 2007 to women who were registered in the IHDSS.

2.5.2 EXCLUSION CRITERIA

All children born before 1st January, 2005 or after 31st December, 2007

All children born before their mothers became members in the HDSS households.

2.6 MEASUREMENT

2.6.1 GENERAL

Ifakara Health and Demographic Surveillance System employed a Household Registration System (HRS), which involved collecting, and documenting data on pregnancies and births, deaths, in and out-migrations. Household Socio-economic status data including ownership of assets and house construction materials were collected once annually using the Principal Component Analysis (PCA) technique. Assets included hoes, cutlass, bed, video, mattress, sheep, bicycle, etc. Verbal autopsy was also conducted on all Ifakara HDSS registered deaths using specific standard questionnaires which were used to determine cause of death.

2.6.1.1 PRINCIPAL COMPONENT ANALYSIS (PCA)

Principal Component Analysis (PCA) is a statistical procedure that linearly transforms a large set of variables into a smaller number of uncorrelated variables that retain most of the information contained in the original data set. In theory, income, consumption and expenditure can be taken as a measure of household wealth. However, it is rigorous in collection of accurate income and consumption data. Household assets are therefore used as proxy for determination of its wealth (34). PCA is used to estimate a wealth index based on household asset data (bicycles, animals, houses, hoes, radios etc) in creating socio-economic status (SES) indices. Subsequently, the IHDSS households were classified into wealth index quintiles (least poor, less poor, poor, poorer, poorest) based on the wealth indices created. In India, PCA was used to proxy wealth by constructing a linear index from asset ownership indicators to derive weights in estimating the relationship between household wealth and children enrolment (35).

2.6.2 BIRTH ORDER

Birth order was defined as the birth positions of a live birth to a specific woman in relation to her other births.

During household visitation all birth outcomes were reported in a specific form. The pregnancy outcome event was captured by asking the respondent whether there had been any event associated with pregnancy within the past four months. If the response was yes, a series of questions were asked. The questions included date of the pregnancy outcome, type of outcome (a live or non-live birth), single or multiple deliveries, birth order (if a live birth) and place of delivery (***health facility; if the birth took place at any health facility, home; if the birth took place other than a health facility***).

2.6.2.1 QUALITY CONTROL OF DATA COLLECTION

Weekly, 5% to 10% of the households are revisited by field supervisors and repeat interviews on selected variables. Data processing from the field is also done weekly, and any errors detected are sent back to the field for correction by the interviewer.

2.7 DATA PROCESSING METHODS AND ANALYSIS PLAN

2.7.1 DATA ENTRY AND QUALITY

The core DSS data were entered in a relational database (HRS) written in Foxpro with in-built consistency and range checks. Socio-economic status and education data were entered into a computer by two data entry clerks. A verification program was run to verify the data entries between the two data entry clerks. Range and consistency programs were run to check for ranges and consistencies.

2.7.2 DATA ANALYSIS PLAN

2.7.2.1 DATA EXTRACTION

Stat transfer software was used to transfer the required datasets notably Membership, Socio-economic, Pregnancy outcome, Education, and Verbal Autopsy from Visual Foxpro^{FM} to Stata Version 10.0 for merging of the appropriate datasets. The variables that were extracted are:

1. **Outcome Variable**: The main outcome variable was infant death, defined as death of a child before its first birth day.
2. **Main Explanatory Variable:** The main explanatory variable was birth order (1, 2-5, >=6), defined as the birth position of a live birth to a specific woman in relation to her other births.
3. **Other Explanatory Variables:** The other explanatory variables used in the study were maternal education (none, incomplete primary, complete primary, beyond primary), sex of infant (male, female), maternal age in years at delivery (<20, 20-34, >=35), and maternal

socio-economic status (Poorest, Poorer, Poor, Less poor, Least poor), place of birth (home, health facility), twins (1, 2, or more).

2.7.2.2 DATA MANAGEMENT

This study used four main datasets from the IHDSS:

1. Member: This dataset include records of each individual who has ever been registered in the HDSS. The individual information includes, name, sex, date of birth, Relationship to the head of household, entry date, exit date (if exited), type of entry, type of exit, mother and father Ids (if co-residents in the household), husband Ids (for women with a co-resident husband).

2. Social economic status: A household level records about asset ownership and construction materials of the house. (Appendix 3)

3. Pregnancy outcome: Records about each pregnancy outcome includes type of the outcome (live or non-live birth), date of the outcome, sex of the child, place of delivery, who assisted delivery, birth order, singleton or twins, child Id, mother and father IDs. (Appendix 4)

4. Education: Records the completed number of years of education

Household identification number was constructed from individual data using the village attribute and the household number. The unique identification of households and unique identification of individuals were then used to link appropriate datasets. (Appendix 5)

2.8 DATA ANALYSIS

To ease the analysis and the interpretation of the final results, some continuous variables were categorized before starting the analysis. Age of mother at birth of index child was categorized into three age groups - less than 20years, 20 to 34 years and 35 years and more. Some categorized variables were further edited by combining some of their groups in one or two groups either because of the small number observations in those categories or to make the analysis and the interpretation more meaningful. These variables include: birth order where orders 2-3 and 4-5 were combined and thus categorized as 2 -5 (1, 2-5, 6+) – [There were not much difference between birth order 2-3 and 4-5 and so combined them. For the graphs produced for birth orders 1, 2-3, 4-5, 6+ there was overlapping for orders 2-3 and 4-5 and so combined for order 2-5, an arbitrary decision taken]; household head occupation, where occupations like business, small business were also combined into one group named “business”. Records with missing values in the case of antenatal care delivery and twin births were excluded in the analysis.

Descriptive statistics was computed to describe maternal demographic characteristics. This was done by conducting distribution table and calculating the frequency and proportion of live births and infant deaths in each category within the selected explanatory variables. Chi-square (x^2) test was used to compare infant deaths by birth order. Bivariate Poisson regression models were used to measure the association between infant mortality and birth order with unadjusted relative risk at 5% statistical significance, and also to measure the association between infant mortality and each of the maternal characteristics (i.e. maternal age at birth, maternal education, social-economic status, sex of infant, place of birth, twin births). Multivariate Poisson regression models were also used to measure the association between infant mortality and birth order with adjusted relative risks at 5% level of significance. The various maternal characteristics and potential confounders were adjusted for in the multivariate Poisson regression models.

2.8.1 WHY POISSON REGRESSION MODEL?

Poisson regression seeks to model **counts**—in this study, the number of infant deaths. It models the (natural) log of the expected number of infant deaths. However, since infants were observed for varying length of time, Poisson regression was used to model **counts per unit time** through an offset, a variable that is forced to have a regression coefficient of 1.

2.8.2 POISSON REGRESSION MODEL (GERARD E. DALLAL, 2008)

The Poisson regression coefficient represents the change in response corresponding to a one unit difference in the corresponding predictor. Here, the response is expected (natural) logged count.

In general,

$when\ Xi = x$

$\log count\ Xi = x$

$= b0 + b1X1 + biXi + \cdots + bpXp \quad --------------(1)$

while

$when\ Xi = x + 1$

$\log count\ \ Xi = x + 1$

$= b0 + b1(x + 1) + bi(x + 1) + \cdots + bpXp\ -----------(2)$

Subtracting the first equation from the second gives

$(\log count\ Xi = x + 1) - (\log count\ Xi = x) = bi$

and exponentiating both sides gives

$((\log \ [count\ Xi = x + 1] \ ))/((\log \ [count\ Xi = x] \ )) = \ e\text{^}(bi)$

Thus, the exponentiated Poisson regression coefficient is a **rate ratio** (RR) corresponding to a one unit difference in the predictor.

Exposure Time (Time on Study)

In our study, since not everyone was observed for the same length of time, instead of modelling number of infant deaths per live births we rather modelled number of infant deaths per person-year. The offset here contains the (natural) logarithm of the time on study. Then, the fitted equation then became

$$\log(count) = b0 + b1X1 + biXi + \cdots + bpXp + \boldsymbol{log(time)}$$

$$\log(count) - \log(time) = b0 + b1X1 + biXi + \cdots + bpXp$$

$$log\frac{(count)}{(time)} = b0 + b1X1 + biXi + \cdots + bpXp$$

$$\log \boldsymbol{rate} - b0 + b1X1 + biXi + \cdots + bpXp \text{ ;}$$

where $X1, X2, \ldots Xp$ are the predictors (birth order, sex, ….., twin birth)

2.9 ETHICAL CONSIDERATIONS

The original study had ethical clearance from the Ifakara Health Institute Ethics Committee. This protocol had ethical clearance from the University of the Witwatersrand's Committee for Research on Human Subjects (Medical) in South Africa (Appendix 1) and the Institutional Review Board of the Ifakara Health Institute, Tanzania (Appendix 2).

2.10 DISSEMINATION PLANS

The findings of this study would be made available to Ifakara Health Institute. Presentations of the findings of this study would be done in the academic and scientific meetings of the University of the Witwatersrand’s School of Public Health, South Africa and Kintampo Health Research Centre, Ghana. The findings would also be disseminated to the communities whose data were used for the study through the DSS newsletter.

CHAPTER THREE: RESULTS

This chapter is presented in two parts: the descriptive analysis of maternal demographic and study population characteristics using tables and graphs; and the inferential analysis where associations of outcome and exposure variables are determined using the Poisson bivariate and multivariate regression models. Proportional mortality by causes of infant deaths for the study period is also described using graphs at the latter part of the chapter.

3.1 Description of maternal demographic and study population characteristics

The study recruited a total of 8,916 live births born in the Ifakara Health and Demographic Surveillance Site (IHDSS) from 2005 to 2007 with a total of 562 infant deaths. The summary of maternal demographic and study population characteristics is as shown in table 1. The male/female ratio showed that the frequency of male births was slightly higher than that of female births (51% versus 49%; sex ratio 1.04). Most children were born to mothers aged 20 and 34 years (68%) whilst 15% of children were born to mothers of age 35 years and above. The average maternal age at birth of the index child was 26.5 years. Singleton births accounted for 96% of all births.

The major occupation of the household heads was farming (81%) while the least was driving (<1%). 5,647 (63%) of the children were born to the birth order category of 2 – 5; 1,679 (19%) to the first birth order category whilst 1,590 (18%) to the 6^{th}-and-above birth order category. Majority of the children were born in a health facility (60%) while 40% were born at home. The number of mothers who attended antenatal care (ANC) was 7552 representing 98% while 128 (2%) of mothers did not attend ANC. However, ANC data did not provide information on early or late visit during pregnancy [ANC information on 1236 (15%) women was missing]. Mothers who gave singleton births were 96% while 4% gave birth to twins.

At least 57% of the women had completed primary education or beyond while 25% had attended primary education but could not complete. 16% of the women had however no formal education. 62%

of the women were assisted by health professionals (Doctors/nurses) during delivery with 24% receiving assistance from TBAs. Some women (7%) were assisted by their friends or relatives while 5% were assisted by neighbours. Other women (2%) were able to give birth by themselves. More respondents came from poor (23%) than poorest household (17%).

Table 2 shows the percentage distribution of births by birth order. In general, about 19% of infants were of first birth, 63% were of second-to-fifth births while about 18% were of sixth-and-above birth order. About 64% of female infants were second to fifth births compared to 63% of their male counterparts in the same birth order. 70% of first births were born to mothers of less than 20 years while women aged 20 to 34 years had about 9% first births. About 85.5% of second-to-fifth births were born to women aged 20 to 34 years while about 8.1% of the same birth order category was born to women of age less than 20 years. Higher births of six-and-above of about 58.8% were however born to women aged 35 or more years.

The distribution of births by place of delivery according to selected variables is presented as Appendix 6. We found that across all maternal age categories, majority of the births occurred at health facility (60%) with about 67% births from mothers of age between 20 and 34 years. Elder women had about 16% of all home births. At 59% of all health facility deliveries were from women with at least completed primary education as against 55% of all home deliveries.

Also the distribution of birth by type of assistance present at delivery according to selected characteristics is presented as Appendix 7. We saw that regardless of the mother's age, majority of the deliveries were assisted by health professional (62%), while TBAs contributed to about 24% of the deliveries. 5% of the women received assistance from neighbours while relatives and friends contributed to about 8% of total deliveries. Only few women gave birth without assistance. For women who had no formal education, 63% of them received delivery assistance from health professional while 2% had no assistance.

Table 1: Distribution of live births by explanatory factors

Variable	Category	Frequency	Total	Percentage (%)
Birth order				
	1	1,679		19
	2-5	5,647		63
	6+	1,590	**(8916)**	18
Sex				
	Female	4,364		49
	Male	4,552	**(8916)**	51
Birth place				
	Health facility	5,342		60
	Home	3,574	**(8916)**	40
Maternal age (yrs)				
	<20	1,551		17
	20 – 34	6,053		68
	35+	1,312	**(8916)**	15
Twin birth				
	Yes	323		4
	No	8,589	**(8912)**	96
Antenatal care (ANC)				
	Yes	7,552		98
	No	128	**(7680)**	2

Variable	Category	Frequency	Total	Percentage (%)
Maternal education				
	Beyond primary education	168		2
	Complete primary education	5,106		57
	Incomplete primary education	2,213		25
	No formal education	1,429	**(8916)**	16
Delivery assistance				
	Doctor/nurse	5,512		62
	TBA	2,181		24
	Neighbour	416		5
	No one	205		2
	Other	602	**(8916)**	7
Household head occupation				
	Employed (salary)	192		2
	Farmer	7,200		81
	Fisherman	333		4
	Business	1040		12
	Driver	21		0
	Mason	130	**(8916)**	1
Wealth index				
	Least poor	1,497		20
	Less poor	1,728		21
	Poor	2,034		23
	Poorer	1,852		19
	Poorest	1,805	**(8916)**	17

Table 2: Percentage distribution of live births by birth order

Variable	Birth Order (N, %)		
	1	***2-5***	***6+***
Sex			
Female	810 (48.2)	2780 (49.2)	774 (48.7)
Male	869 (51.8)	2867 (50.8)	816 (51.3)
Birth place			
Health facility	1183 (70.5)	3324 (58.9)	835 (52.5)
Home	496 (29.5)	2323 (41.1)	755 (47.5)
Maternal age (yrs)			
<20	1091 (65.0)	460 (8.1)	0 (0.0)
20 – 34	572 (34.0)	4826 (85.5)	655 (41.2)
35+	16 (1.0)	361 (6.4)	935 (58.8)
Twin birth			
Yes	32 (1.9)	211 (3.7)	80 (5.0)
No	1647 (98.1)	5433 (96.3)	1509 (95.0)
Antenatal Care (ANC)			
Yes	1420 (98.9)	4791 (98.4)	1341 (97.6)
No	15 (1.1)	80 (1.6)	33 (2.4)
Maternal education			
Beyond primary education	56 (3.3)	99 (1.8)	13 (0.8)
Complete primary education	878 (52.3)	3334 (59.0)	894 (56.2)
Incomplete primary education	509 (30.3)	1316 (23.3)	388 (24.4)
No formal education	236 (14.1)	898 (15.9)	295 (18.6)

Variable	Birth Order (N, %)		
	1	***2-5***	***6+***
Delivery assistance			
Doctor/nurse	1034 (61.6)	3475 (61.5)	1003 (63.1)
TBA	412 (24.5)	1396 (24.7)	373 (23.5)
Neighbour	87 (5.2)	271 (4.8)	58 (3.7)
No one	42 (2.5)	120 (2.1)	43 (2.7)
Other	104 (6.2)	385 (6.8)	113 (7.1)
Household Head Occupation			
Employed (salary)	37 (2.2)	114 (2.0)	41 (2.6)
Farmer	1367 (81.4)	4556 (80.7)	1277 (80.3)
Fisherman	51 (3.0)	208 (3.7)	74 (4.7)
Business	196 (11.7)	671 (11.9)	173 (10.9)
Driver	5 (0.3)	13 (0.2)	3 (0.2)
Mason	23 (1.4)	85 (1.5)	22 (1.4)
Wealth index			
Least poor	317 (18.9)	884 (15.7)	296 (18.6)
Less poor	341 (20.3)	1060 (18.8)	327 (20.6)
Poor	353 (21.0)	1323 (23.4)	358 (22.5)
Poorer	340 (20.3)	1186 (21.0)	326 (20.5)
Poorest	328 (19.5)	1194 (21.1)	283 (17.8)

3.2 Mortality Analysis

There were 562 infant deaths from a total of 8916 live births. Of those who died, 308 (54.8%) were males while 254 (45.2%) were females (Table 3). With regards to birth order, first births category had the largest proportion of infant deaths (8.3%). Children born to young women of age less than 20 years had 7.2% of infant death while the least infant deaths (6.0%) came from women aged 20 t0 34 years. In proportion, twin deaths (18%) were more common than singleton deaths (5.8%). Also mothers without formal education had larger proportion of infant deaths (7.6%) with the least deaths coming from mothers who had attained education beyond primary (5.4%). Women who were not assisted during delivery experienced the highest proportion of infant death (7.3%) while the least came from women who were assisted by relatives or friends. Fishermen had the highest proportion of infant death (8.1%).

From Table 3, twin birth was highly associated with infant mortality ($p<0.001$).

The Neonatal Mortality Rate (NMR) ranged from a maximum of 40.2 per 1000 person-years in 2005 to a minimum of 35.6 per 1000 person-years in 2007. The overall NMR for the three year period was 38.3 per 1000 person-years. However, the Infant Mortality Rate though showed an initial decrease from a maximum of 81.9 per 1000 person-years in 2005 to a minimum of 63.7 per 1000 person-years in 2005, it increased to 64.9 per 1000 per person-years in 2007. The average IMR was 70.1 per 1000 person-years (Table 4)

Table 3: Distribution of infant deaths by explanatory variables

Variable	Category	Live births (N=8916)	Dead (%)	p-value
Birth Order				
	1	1,679	122 (8.3)	
	2-5	5,647	337 (6.0)	0.15
	6+	1,590	103 (6.5)	
Sex				
	Female	4,364	254 (5.8)	
	Male	4,552	308 (6.8)	0.07
Birth place				
	Health facility	5,342	329 (6.2)	
	Home	3,574	233 (6.5)	0.49
Maternal age (yrs)				
	<20	1,551	111 (7.2)	
	20 – 34	6,053	362 (6.0)	0.17
	35+	1,312	89 (6.8)	
Twins				
	Yes	323	58 (18.0)	
	No	8,589	500 (5.8)	<0.001
Antenatal care (ANC)				
	Yes	7,552	469 (6.2)	
	No	128	8 (6.3)	0.99
Maternal education				
	Beyond primary education	168	9 (5.4)	
	Complete primary education	5,106	303 (5.9)	
	Incomplete primary education	2,213	141 (6.4)	0.13
	No formal education	1,429	109 (7.6)	

Variable	Category	Live births (N=8916)	Dead (%)	p-value
Birth assisted by				
	Doctor/nurse	5,512	341 (6.2)	
	TBA	2,181	147 (6.7)	
	Neighbour	416	24 (5.8)	0.80
	No one	205	15 (7.3)	
	Other	602	35 (5.8)	
Household Head Occupation				
	Employed (salary)	192	15 (7.8)	
	Farmer	7,200	458 (6.4)	
	Fisherman	333	27 (8.1)	
	Business	1040	51 (4.9)	0.13
	Driver	21	0	
	Mason	130	11 (8.5)	
Wealth index				
	Least poor	1,497	98 (6.6)	
	Less poor	1,728	99 (5.7)	
	Poor	2,034	116 (5.7)	0.27
	Poorer	1,852	118 (6.4)	
	Poorest	1,805	131 (7.3)	

Table 4: Neonatal and Infant Mortality Rate: 2005 – 2007 in IHDSS, Tanzania

	Live Birth		Neonatal Mortality		Infant Mortality	
Year	***No.***	***Person-Years Observed***	***Deaths***	***Rate***	***Deaths***	***Rate***
2005	2977	2661.66	107	40.2	218	81.9
2006	2967	2685.80	105	39.1	171	63.7
2007	2972	2666.99	95	35.6	173	64.9
All Year	**8916**	**8014.45**	**307**	**38.3**	**562**	**70.1**

Table 5: Neonatal and Infant Mortality Rate by birth order in IHDSS from 2005 - 2007, Tanzania

	Live Birth		Neonatal Mortality		Infant Mortality	
Year	***No.***	***Person-Years Observed***	***Deaths***	***Rate***	***Deaths***	***Rate***
1	1679	1446.26	65	44.9	122	84.4
2 - 5	5647	5109.66	185	36.2	337	66.0
6+	1590	1458.54	57	39.1	103	70.6
Overall	**8916**	**8014.46**	**307**	**38.3**	**562**	**70.1**

We found that first births and children of birth order 6 and above were of higher mortality rates than those of birth order of between 2 and 5 inclusive (Table 5).

As to who assisted mothers to deliver their babies, we found that self deliveries had the highest infant mortality rate (80.2), followed by TBAs (75.2) and Doctors/nurses (68.8). Delivery assistance from neighbours and other sources (relatives/friends) had the least infant mortality rates of 65.1 and 64.2 respectively. Figure 2.

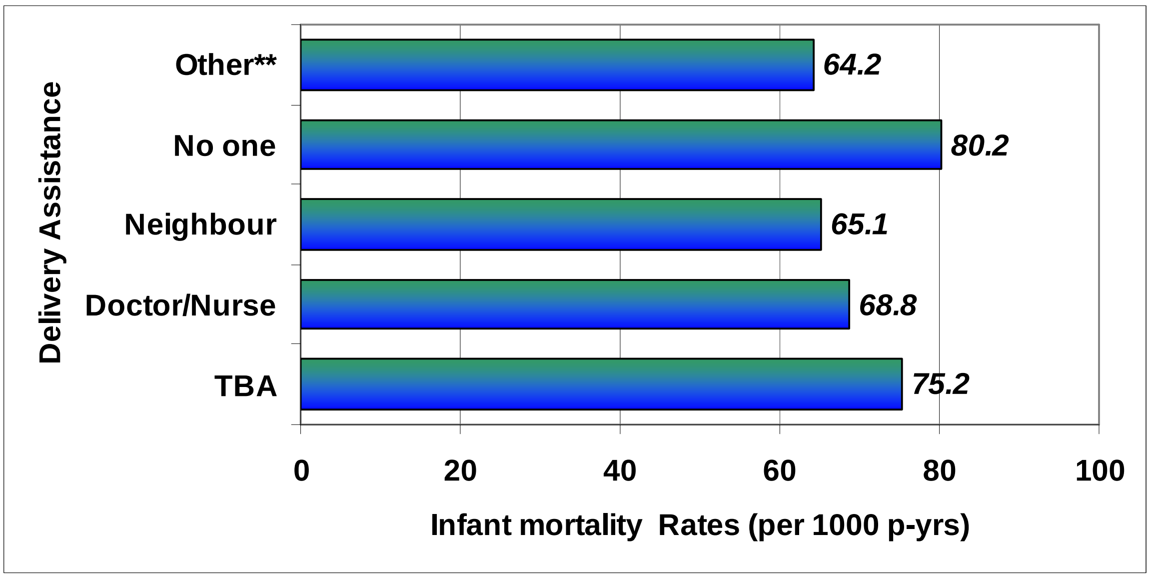

Figure 2: Distribution of IMR by Delivery Assistance source from 2005 to 2007, IHDSS. (** mothers, sisters)

Mothers who attended antenatal care (ANC) before delivery had higher infant mortality rate (69.1) than those who did not attend ANC (67.5) Figure 3. Mothers younger than 20 years (at birth of the index child) had highest infant mortality rate (81.9). Those of age between 20 and 34 years old had the least infant mortality rate (66.2) followed by mothers of age 35 years or more (74.6) (figure 4).

Also, women who delivered at home had the higher infant mortality rate (72.2) as compared to those who delivered at a health facility (68.1).

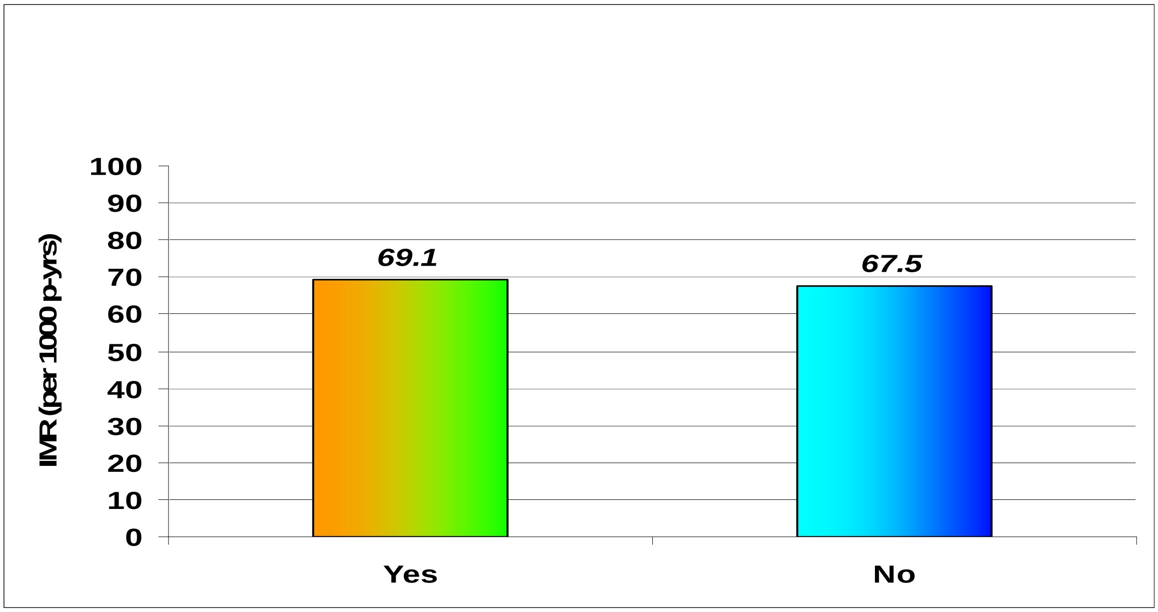

Figure 3: Distribution of IMR by antenatal care delivery from 2005 to 2007, IHDSS

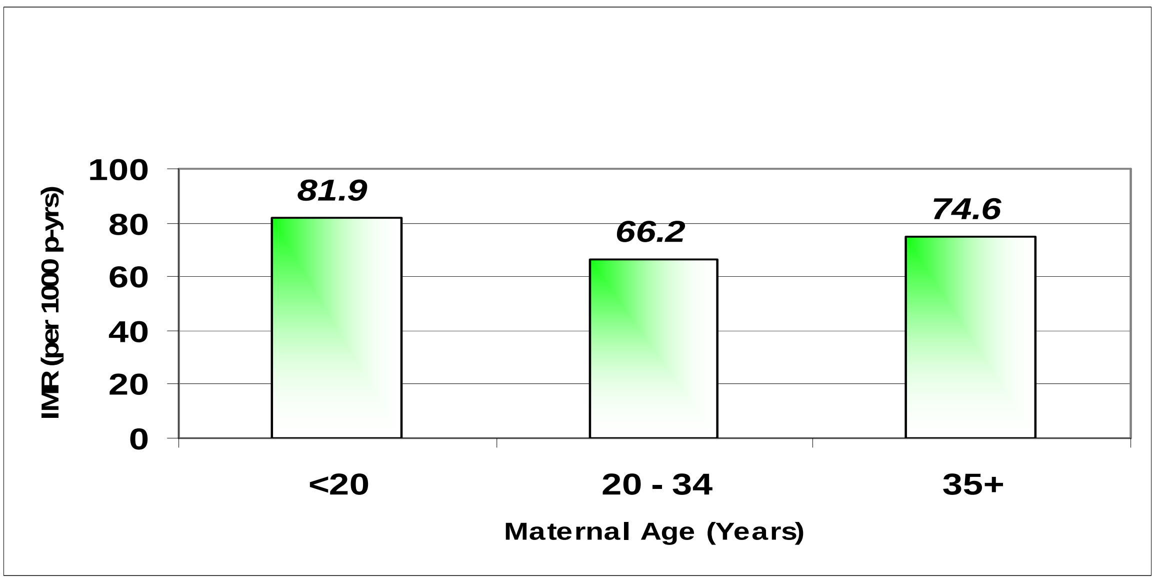

Figure 4: Distribution of IMR by Maternal age at birth of index child from 2005 to 2007, IHDSS

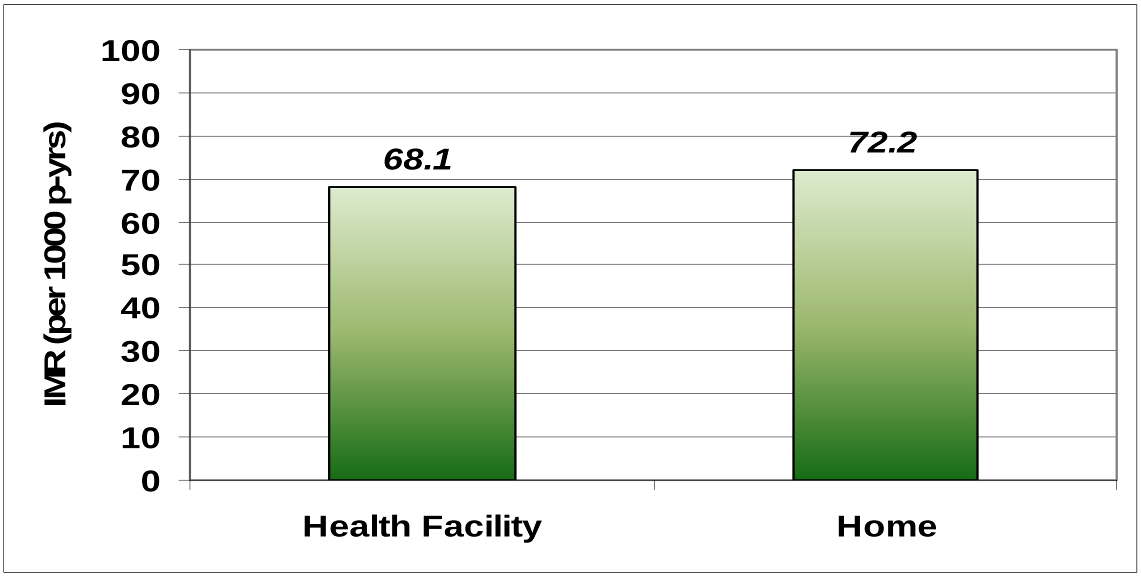

Figure 5: Distribution of IMR by place of birth from 2005 to 2007, IHDSS

3.3 Survival Analysis

The curve (Figure 6) shows the overall survival probability of infants after birth. There were 136 infant deaths on the day of birth representing the sharp drop of the survival curve at the beginning. The survival probability dropped instantly from 1.0 to about 0.99, then from 0.983 to about 0.973. There was then a steady drop in infant survival probability till it dropped to 0.94. There were 171 more infant deaths within the first four weeks totalling 307 neonatal deaths. A further 255 infants died during the post-neonatal period showing the decline of infant survival.

Stratifications by sex and birth order are shown in figures 7 and 8 respectively. Females had the same pattern but higher survival probability throughout infancy as compared to their male counterparts (figure 7). Studies have shown that sex differentials in infant mortality vary widely across nations. Newborn girls are biologically advantaged in surviving to their first birthday, sex differentials in infant mortality typically arise from genetic factors that result in higher male infant mortality rates (36). On the other hand second-to-fifth birth order had higher survival probability than first births and 6 or more birth orders (figure 8). Singleton births had a higher survival probability than twin births (figure 9).

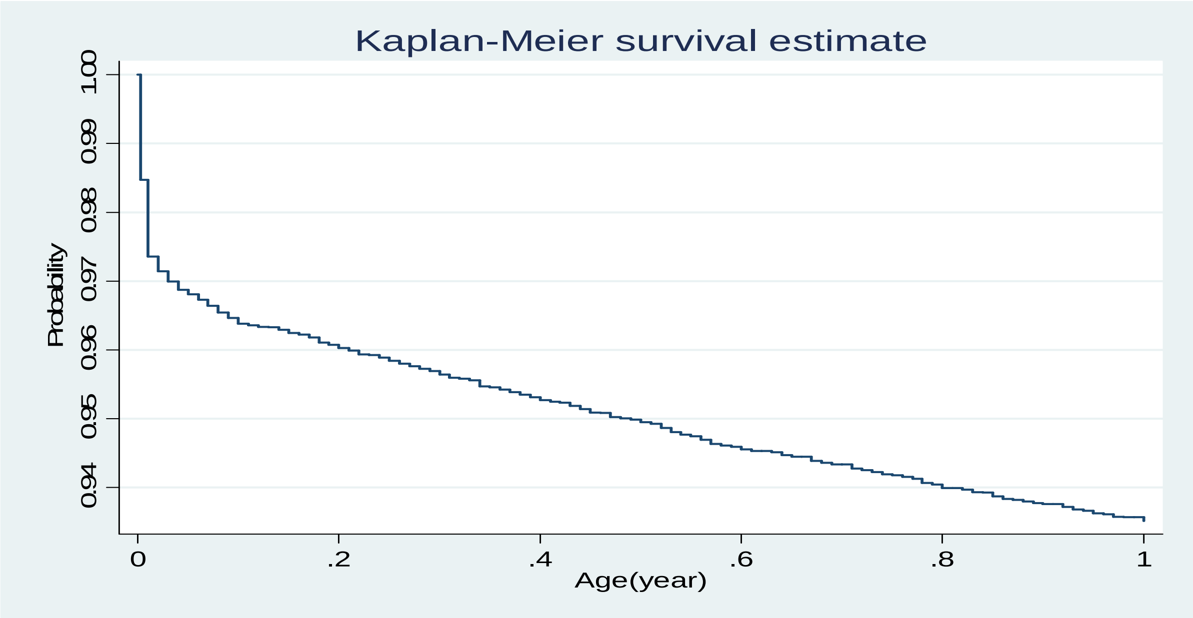

Figure 6: Kaplan-Meier Survival estimates for infants born from 2005 to 2007, IHDSS

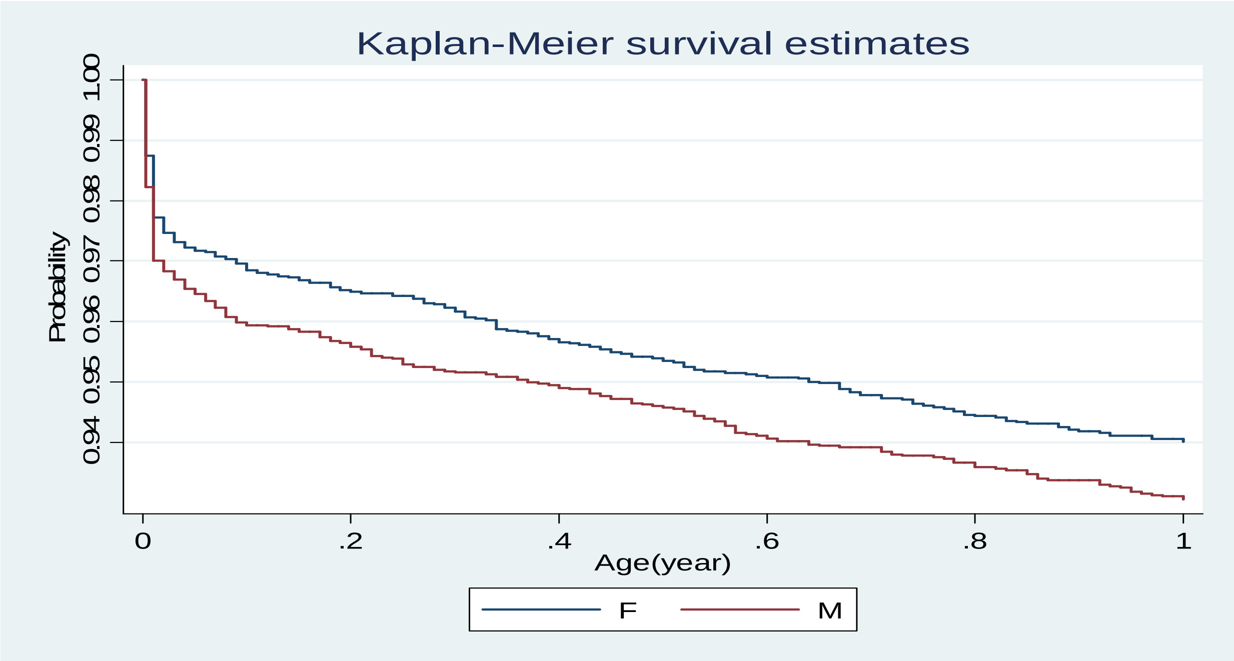

Figure 7: Kaplan-Meier Survival estimates by sex from 2005 to 2007, IHDSS

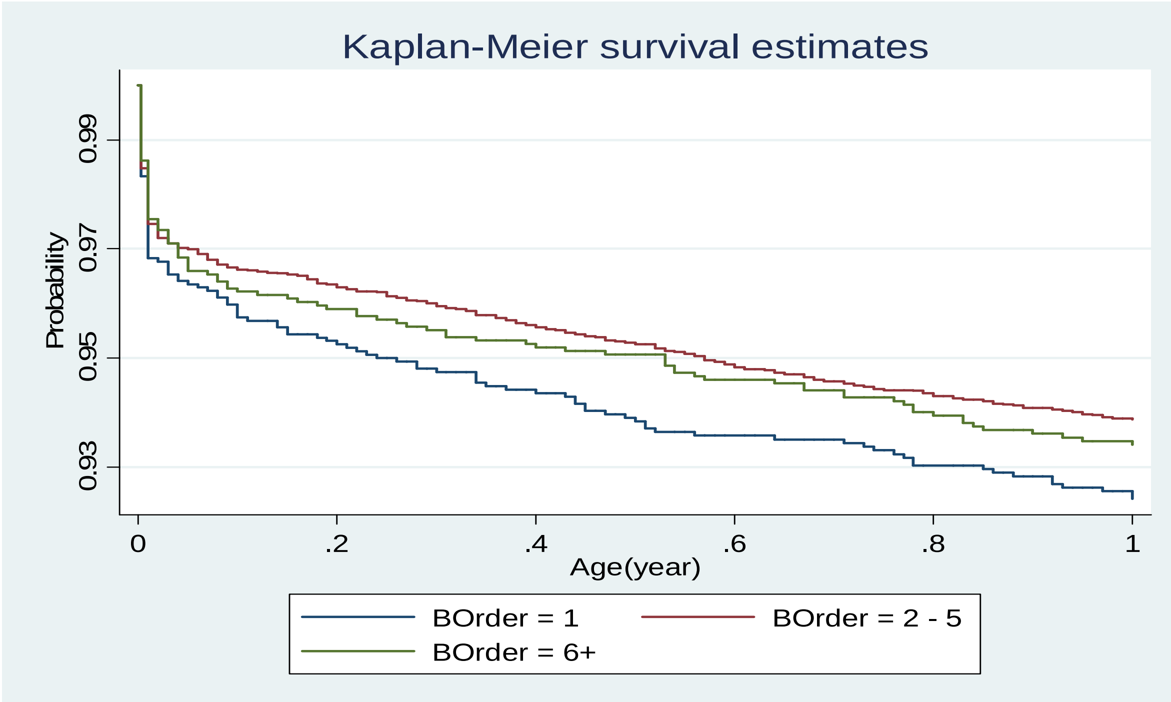

Figure 8: Kaplan-Meier Survival estimates by birth order from 2005 to 2007, IHDSS

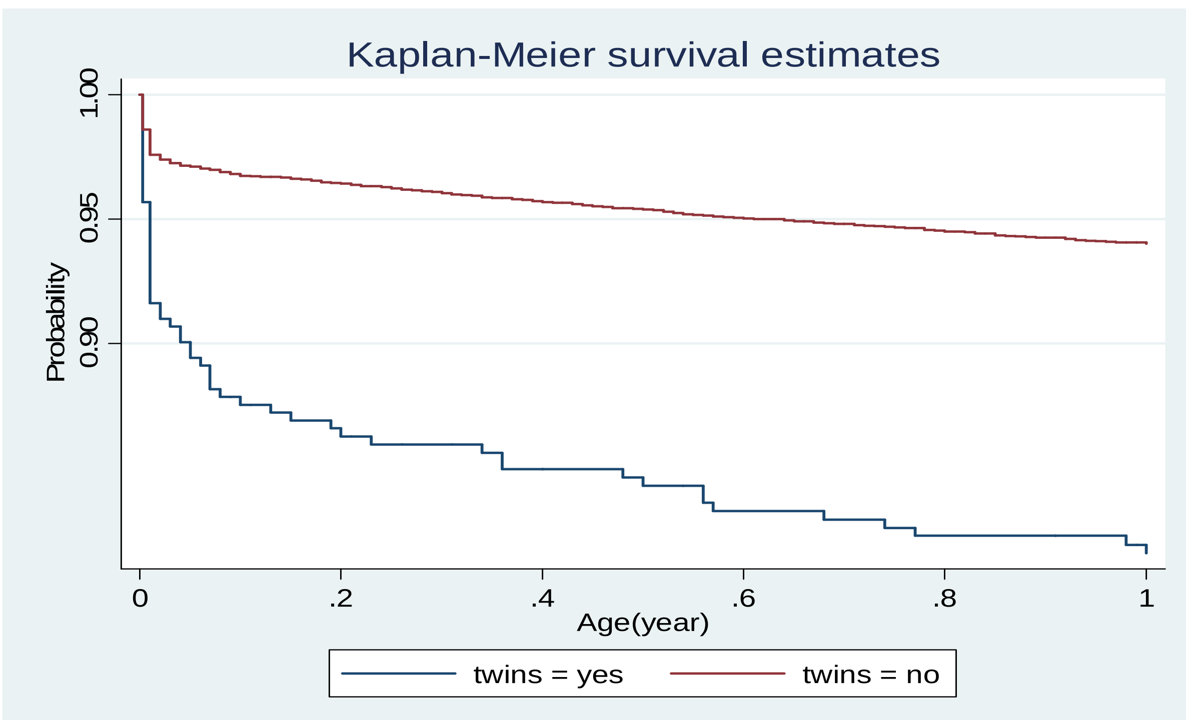

Figure 9: Kaplan-Meier Survival estimates by twin birth from 2005 to 2007, IHDSS

3.4 Risk Analysis

To examine the association between birth order and infant mortality, and to identify other risk factors associated with infant mortality, a Poisson regression of infant deaths was run over each of the explanatory variables.

The results are as shown in table 6. In the Poisson bivariate analysis, factors that were significantly associated with risk of infant mortality included first birth order, maternal age of <20 years and twin births. Birth orders of 2 – 5 and sixth-and-above, maternal age at birth of index infant of 20 to 34 years and 35 or more years and singleton births were negatively associated with infant mortality. However, sex, birth place, ANC, maternal education, delivery assistance by, household head occupation, and wealth index were not significantly associated with infant mortality.

Table 6: Bivariate and Multivariate Poisson Regression Analysis for Infant Mortality

	Bivariate (Unadjusted)			Multivariate (Adjusted)		
Variable	IRR	95% CI	P-value	IRR	95% CI	P-value
Birth Order						
1	1	-	-	-	-	-
2-5	0.78	(0.64 0.96)	**0.02**	0.79	(0.61 1.03)	0.08
6+	0.84	(0.64 1.09)	0.18	0.76	(0.53 1.09)	0.13
Sex						
Female	1	-	-	1	-	-
Male	1.17	(1.00 1.38)	0.06	1.17	(0.99 1.38)	0.07
Birth place						
Health facility	1	-	-			
Home	1.05	(0.89 1.24)	0.56			
Maternal age (yrs)						

<20	1	-	-	1	-	-
20 – 34	0.81	(0.65 1.00)	**0.05**	0.89	(0.68 1.16)	0.40
35+	0.91	(0.69 1.20)	0.51	1.06	(0.72 1.54)	0.76
Twins						
Yes	1	-	-	1	-	-
No	0.29	(0.22 0.37)	**<0.001**	0.28	(0.21 0.36)	**<0.001**
ANC						
Yes	1	-	-			
No	0.98	(0.49 1.97)	0.95			
Maternal education						
Beyond primary	1	-	-			
Complete primary	1.08	(0.56 2.10)	0.82			
Incomplete primary	1.16	(0.59 2.28)	0.66			
None	1.41	(0.72 2.79)	0.32			
	Bivariate (Unadjusted)			Multivariate (Adjusted)		
Variable	IRR	95% CI	P-value	IRR	95% CI	P-value
Delivery assistance						
Doctor/nurse	1	-	-			
TBA	1.09	(0.90 1.33)	0.36			
Neighbour	0.95	(0.63 1.43)	0.80			
No one	1.17	(0.70 1.96)	0.56			
Other	0.93	(0.66 1.32)	0.70			
Household Head Occupation						
Employed (salary)	1	-	-			
Farmer	0.80	(0.48 1.34)	0.40			
Fisherman	1.02	(0.54 1.92)	0.95			
Business	0.61	(0.34 1.09)	0.09			
Driver		(No failures)				

Mason	1.07	(0.49 2.34)	0.86
Wealth index			
Least poor	1	-	-
Less poor	0.85	(0.65 1.13)	0.27
Poor	0.85	(0.65 1.11)	0.22
Poorer	0.96	(0.73 1.25)	0.75
Poorest	1.10	(0.84 1.43)	0.49

Birth orders indicated that infants who were first births to their mothers faced a significantly high risk of dying compared to higher birth orders. Those born in the order 2-5 had a statistically significant reduced risk dying of about 22% compared to the first births (IRR=0.78, 95%CI: 0.64, 0.96; p=0.05). Infants in the birth order 6 or above had a reduced risk of dying of about 16% compared to the first births but was not statistically significant (IRR=0.84, 95%CI: 0.64 , 1.09) for 6 and above category.

From the bivariate analysis, we found that male infants were about 17% more at risk of dying (IRR=1.17, 95%CI: 0.10, 1.38) though not statistically significant as compared to their female counterparts.

Mothers who were aged 20-34 years had 19% marginally significant protective effect for their children (IRR=0.81, 95%CI: 0.65, 1.00, p=0.05) while those aged 35 years or above had 9% reduced risk of infant deaths as compared to mothers who were less than 20 years of age. Singleton births had 71% highly statistically significant reduced risk of infant deaths as compared to twin births (IRR=0.29, 95%CI: 0.22, 0.37; p<001).

Although other factors like birth place, antenatal care, maternal education, delivery assistance, household head occupation and wealth index did not significantly influence infant mortality in this study, we included in the analysis for future study into them.

We realised that mothers who did not attend antenatal care (ANC) had about 2% reduced risk of dying (IRR=0.98, 95%CI: 0.49, 1.97) but not statistically significant as compared to mothers who attended ANC.

As to maternal education, we found that mothers who did not have formal education were 1.4 times at risk of having infant deaths (IRR=1.41, 95%CI: 0.72, 2.79) but not statistically significant as compared to those who had education beyond primary. Also those who either had complete or incomplete formal education were 8% (IRR=1.08, 95%CI: 0.56, 2.10), or 19% (IRR=1.19, 95%CI: 0.59, 2.28) more likely to have infant deaths respectively as compared to those with education beyond primary.

Place of delivery was categorized as either at health facility or home. Factors surrounding delivery included place of delivery and who assisted: those who did not seek any assistance were 1.17 times more at risk of infant death (IRR=1.17, 95%CI: 0.70, 1.96) as compared to those who sort delivery assistance from doctors/nurses. Those who sort assistance from neighbours were less at risk of infant death (6%) compared to doctors/nurses seekers. Other sources of delivery assistance (mothers, sisters, relatives) had 7% reduced risk of infant deaths as compared to assistance from doctors/nurses. Mothers who gave birth at home were slightly (5%) more likely to experience an infant death (IRR=1.05, 95%CI: 0.89, 1.24) as compared to those who gave birth at a health facility.

On occupation of the head of household, we found that infants born to businessmen and farmers had 46% and 20% reduced risk of dying (IRR=0.54, 95%CI: 0.30, 0.98; p=0.04) and (IRR=0.80, 95%CI: 0.48, 1.34) respectively as compared to those born to mothers who were employed. Masons and fishermen were 7% (IRR=1.07, 95%CI: 0.49, 2.34) and 2% (IRR=1.02, 95%CI: 0.54, 1.91) more at risk of experiencing infant deaths as compared to those employed respectively. On the issue of wealth index which is a proxy measure of the relative wealth of a household, the poorest household was 1.1

times more likely to have infant deaths (IRR=1.10, 95%CI: 0.84, 1.43) as compared to the least poor households.

For the multivariate analysis, only the exposure variables that were statistically significant at bivariate analysis were put in the multivariate model notably, birth order, maternal age, and twins. However, sex was included in the multivariate analysis based on evidence from other literature.

After controlling for maternal age, sex and twins, children of birth order 2 to 5 still indicated about 21% reduced risk of infant death compared to first births, however it was no longer statistically significant at 5% level (IRR=0.79, 95%CI: 0.61, 1.03; p=0.08), while those of 6 and above births had 24% reduced risk of infant deaths (IRR=0.76, 95%CI: 0.53, 1.09). Singleton births remained highly at a reduced risk of infant death (72%) as compared to twin births and statistically significant (IRR=0.28, 95%CI: 0.21, 0.36; p <0.001)**.** There were no interactions when we checked for possible interaction terms.

3.5 Causes of Infant Death

Figure 10 shows cause-specific proportional mortality. Malaria was the leading cause of infant death accounting for 30% of all the infant deaths. This was followed by birth injury/asphyxia (16%), Pneumonia (10%) and premature and/or low birth weight (8%). All other perinatal causes (7%), unspecified acute fibrile illness (4%), anaemia (3%) and diarrhoeal diseases (2%) were other causes of infant deaths from 2005 – 2007. AIDS, pulmonary tuberculosis, congenital abnormalities and other diseases constituted to about 20% of all causes of infant deaths.

In 2005 (Appendix 8) malaria ranked highest with 28% of all causes of infant deaths followed by injury/asphyxia (13%), pneumonia (10%), other perinatal causes (8%), unspecified acute fibrile illness (6%), premature and/or low birth weight (5%) and anaemia (4%). All other diseases including diarrhoeal diseases, AIDS, TB/AIDS, Pulmonary Tuberculosis, congenital abnormalities contributed to about 26% of the causes of infant death in 2005.

In 2006, the trend changed (Appendix 9). Malarial causes of infant deaths increased from 28% in 2005 to 42% in 2006. This was followed by Pneumonia (18%), with all other diseases including diarrhoeal diseases, AIDS, Pulmonary Tuberculosis, birth injury/asphyxia, and anaemia constituting to about 40% of all causes of infant death in the said year.

The year 2007 saw causes of malarial infant deaths reducing from 42% in 2006 to 27% in 2007 (Appendix 10). This was followed by birth injury/asphyxia (20%), premature and/or low birth weight (13%), pneumonia (8%) and other perinatal causes (6%). Other causes including AIDS, Diarrhoeal diseases, pulmonary TB, and unspecified acute febrile illness contributed to about 32% of all causes of infant death in 2007.

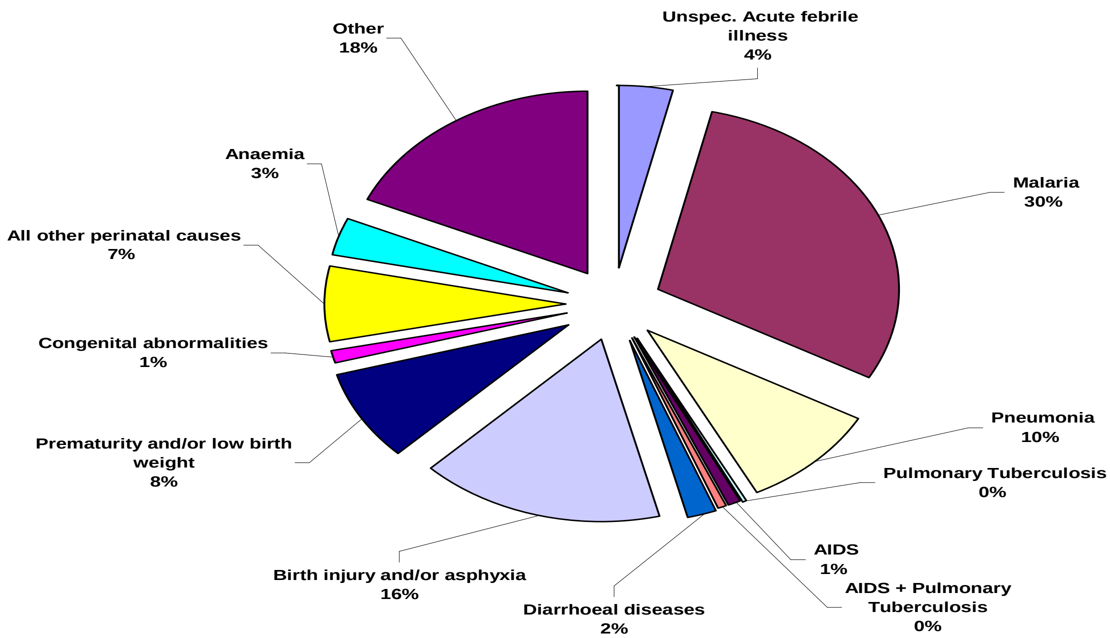

Figure 10: Causes of infant death in IHDSS from 2005 to 2007

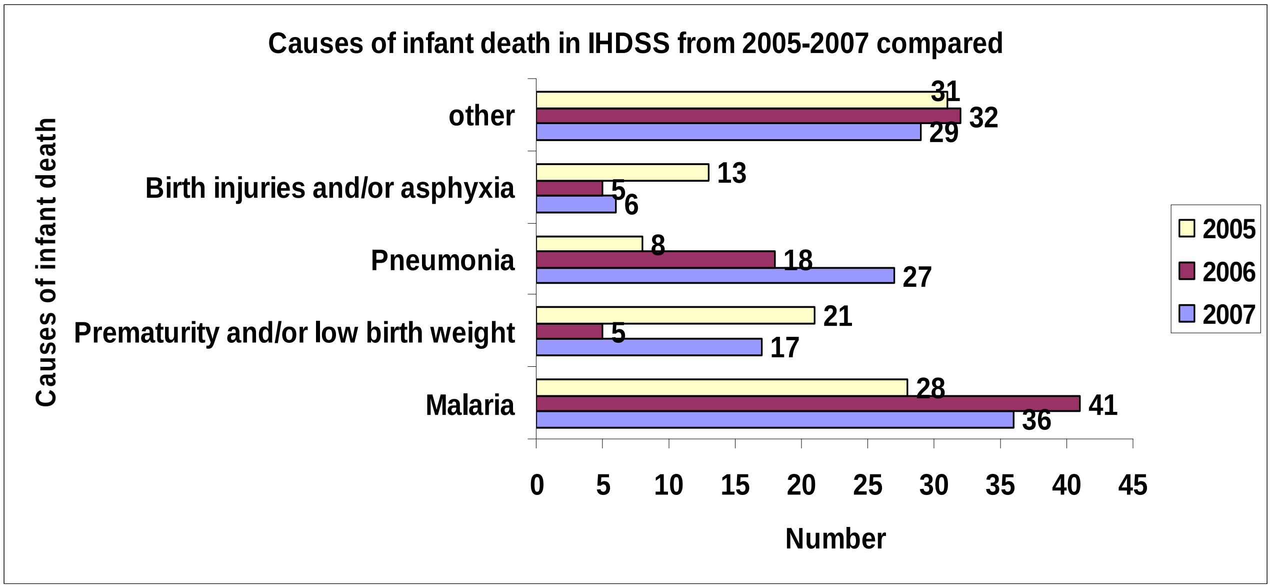

Figure 11: Causes of infant death compared from 2005 to 2007, IHDSS

Figure 11 shows how causes of infant death are compared between the study periods. We realise that malaria increased from 36% in 2005 to 41% in 2006 but dropped remarkably to 28%. Pneumonia continuously decreased across the years from 27% in 2005 to 8% in 2007. Birth injury/asphyxia and premature/low birth weight bow saw a decrease in 2006 but increased again in 2007.

Due to the three year period under study, the number of deaths by specific causes per year was small (figure 11). This could account for fluctuations in cause specific mortality fractions.

CHAPTER FOUR: DISCUSSION

The main objective of this study was to determine the risk factors associated with infant mortality in Ifakara in rural Tanzania from January 2005 to December 2007. Specifically, this study was to describe the distribution of infant mortality by birth order, examine the association between birth order and infant mortality, and to identify other risk factors associated with infant mortality. Further to describe the causes of infant deaths from 2005 to 2007.

This study used Poisson regression modelling to quantify the effect of these risk factors on infant mortality. The results showed that the level of infant mortality rate in rural Tanzania was 70.1 per 1000 person-years while the neonatal mortality was 38.3 per 1000 person-years. Birth order was found to be significantly associated with infant mortality. However, after adjusting for maternal age and twin births, birth order was no longer statistically significant.

4.1 **Predictors of Infant Mortality**

4.1.1 BIRTH ORDER

First births and births of higher orders (6+) are found to be associated with high infant mortality. The influence of birth order on infant mortality is largely dependent on the social, cultural and historical context in which studies are carried out. Society changes with change in the internal lives of families. For instance, as fertility rates decline and family policy improves, the relative advantage of one birth order position over another may vanish or change. Consequently, the influence of birth order on various outcomes does not always appear as a linear pattern, neither does it stand out as a consistent predictor over time (37). Thus in this study, maternal age at birth of the index infant plays an important role in infant mortality through their first births. Furthermore, higher mortality rates among the first and higher order births are due to the fact that the birth order reflects the components of the child's biological endowment.

4.1.2 SEX

This study showed that females have higher survival chances than their male counterparts. Studies have shown that sex differentials in infant mortality vary widely across nations. Newborn girls are biologically advantaged in surviving to their first birthday, sex differentials in infant mortality typically arise from genetic factors that result in higher male infant mortality rates. There are cases where mortality differentials arise from social or behavioral factors where adults deliberately discriminate in favor of boys over girls (36).

Male born babies are also found to have an elevated risk (OR = 1.4, 95%CI, 1.3 – 1.5) of early neonatal mortality as compared to females (38).

4.1.3 MATERNAL AGE AT BIRTH OF INDEX INFANT

In our study, we found that maternal age of less than 20 years was highly associated with infant mortality. This is evidenced by a study conducted to determine the magnitude, trend and to assess risk factors for early neonatal mortality in Muhimbili National Hospital (MNH) in Tanzania. There was a strong association between early neonatal mortality and maternal age at delivery. Mothers aged less than 20 years have a significantly increased risk of infant deaths (AOR=1.3, 95%CI, 1.1 – 1.4); whereas mothers aged 35 to 39 years have a significantly reduced risk of 0.7 (95%CI, 0.6 – 0.9). (38).

4.1.4 MULTIPLE BIRTHS

Our study showed a reduced risk of singleton infant deaths as compared to twins. Twins are more likely to be born with low birth weight. Also multiple births are strongly negatively associated with infant survival (39). Our study also showed that singleton births have a higher survival probability as compared to twin births.

4.1.5 CAUSES OF INFANT DEATH

The major causes of infant deaths in the Ifakara HDSS area were Malaria, Birth injury/Asphyxia, Pneumonia, anaemia, and premature births/low birth weight. Other causes were diarrhoeal diseases, AIDS, congenital abnormalities, pulmonary tuberculosis and other unspecified acute febrile illness. It is reported that globally, about 56 million deaths occur each year, with 10.5 million in children. About one-fifth of the child deaths, result from perinatal causes such as birth asphyxia and birth trauma, and only slightly less from lower respiratory infections. Diarrhoeal diseases kill over 1.5 million children, and malaria, measles and HIV/AIDS each claim between 500,000 and 800,000 children. Some of these causes of infant deaths are termed as leading causes of global disease burden with HIV the leading cause (40). Other studies have shown associations between placental infection, birth weight and infant mortality. For instance, it has been shown that a baby is twice as likely to be born of low birth weight if the mother has an infected placenta at the time of delivery, and that the probability of premature mortality of African newborns in the first year of life is 3 times higher in babies of low birth weight than in those of normal birth weight (41).

4.1.6 PLACE OF DELIVERY AND DELIVERY ASSISTANCE

In our study, we found that place of delivery was either the health facility or home. Home deliveries included any other place of delivery apart from a health facility. About 60% of all deliveries were at the health facility while 40% were home deliveries. Studies have shown that children born in a modern health facility, irrespective of their mother's place of residence, experienced significantly lower rates of infant mortality than those born elsewhere (42). Though home deliveries are not encouraged, some are unplanned home deliveries with reasons of precipitate labour, lack of escort during labour, financial problems at home, family members preference to home deliveries, fear about hospital, worries about cost of care at the hospital, distance of hospital and lack of transportation (43). We however realised from our study that most infant deaths were associated with home deliveries. In a related finding from rural Tanzania, issues of risk and vulnerability such as lack of money, lack of transport, sudden onset of labour, short labour, staff attitudes, lack of privacy, tradition and cultures and the pattern of decision-making power within the household were perceived as key determinants of the place of delivery (44).

Our study also showed that most deliveries were from skilled health personnel including doctors, nurses, or midwives. However, women who gave birth alone were more at risk of infant deaths than any other assisted labour. Surprisingly deliveries from doctors and TBAs also saw high proportions of infant deaths (6%) and (7%) respectively. This difference could be due to the fact that complicated births are more likely to be attended to by doctors or nurses. Traditional birth attendants may not be skilled enough to handle complicated pregnancy related cases at home. Since the study finds that first births and those of higher order have higher risk of infant deaths, women of this category need trained and skilled health personnel. In rural Tanzania, a study to determine factors affecting home delivery showed that mothers with primary and higher education were more likely to deliver at health facility than mothers with no education (RR 1.30, 95% CI 1.23–1.38). Younger mothers were more likely to deliver at a health facility than other age groups (RR 0.89, 95% CI 0.83–0.95). The least poor women were more likely to deliver in a health facility than the poorest with a 7% increase in the risk of delivering in health facility for every increase in wealth quintile (RR 1.07, 95% CI 1.03–1.43) (44)

4.1.7 ANTENATAL CARE ATTENDANCE AND MATERNAL AGE AT BIRTH OF INDEX INFANT

Mothers who did not attend antenatal care had a 2% reduced risk of infant death. Surprising though, studies have shown that most women who attend antenatal care do not go to the health facility for safe delivery. Although the vast majority of women attended ANC services (98%), about 40% gave birth at home. The major barriers reported for home as opposed to facility-based birth include lack of money, distance to the health facility, fear of caesarean section at the health facility and lack of privacy or a dedicated labor room at the health facility. Giving birth at the hospital was perceived by women to be associated with severe delivery complications (45). In a related finding, some women never attended ANC service with reasons of not seeing the need to attend ANC, expenses of transport or the cost of the ANC, belief that the care was not adequate, and distance to the ANC. It was found that adolescent women and women of age more than 34 years were least likely to attend antennal care clinics (46). However, such women sought alternative care during pregnancy from sources such as TBAs, religious persons, or herbalists.

4.1.8 MATERNAL EDUCATION

Our results showed that infant mortality is inversely associated with maternal education. Women who had beyond primary education had lowest infant mortality rate (60 per 1000 live births) while those who had no formal education had the highest rate (85). Several studies have shown association of maternal education and infant mortality. A by Sonalde and Soumya (1998) found that children of mothers who attended primary school were less likely to die than were children of mothers with no education. Children of mothers with a secondary school education were the least likely to experience infant deaths (47).

4.2 LIMITATIONS OF THE STUDY

The following limitations may affect the results of this study;

- A proportion of misreported age at death may include or exclude some deaths within the under one. Age is not reported but date of birth and date of death since the events were picked very close to the occurrence, misreporting of dates is minimal
- Recall bias may also affect the determination of cause of death with the verbal autopsy questionnaire.

- The Ifakara HDSS has no data on HIV/AIDS status of mothers in the 2005-2007 datasets; the study would therefore not be able to assess the relationship of these HIV/AIDS with infant deaths.
- Data on birth weight and birth interval (potential confounder) are incomplete (not available for all children). These two variables have not been included in the analysis.
- The ANC data did not provide information on early or late visit during pregnancy.
- The numbers of deaths as a result of specific causes by single year were small.

4.3 STRENGTHS OF THE STUDY

- The DSS had in provision a high quality longitudinal data on population dynamics
- Data collection was done every 4 months per year
- There were key informants involved in data collection living in communities

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

Infant mortality in the study area is still high. Birth order was associated with infant mortality. However, when adjusted for maternal age and twin birth it was no longer significant for infant mortality. Twin birth is a risk factor for infant mortality.

The health systems should be strengthened, and efforts made to communicate the benefits of health facility deliveries more effectively. Village Health Workers and Traditional Birth Attendants are good interface between the community and the formal health system as such they need to be trained adequately to recognise factors that put infants at risk. There should be re-assessment of preventive strategies already implemented for reducing infant mortality in order to further reduce the infant mortality rate in IHDSS. Special care should be provided for women aged younger than 20 years or over 35 years.

On issue of combating childhood illnesses, the Integrated Management of Childhood Illness (IMCI) conducted in Tanzania showed that facility-based IMCI is good value for money, and support widespread implementation in the context of health-sector reform, basket funding, good facility access, and high utilization of health facilities; thus its implementation in all communities (48).

On the part of birth order, we recommend that the high-risk group, first or sixth or higher pregnancies, need special care and the existing health management system may be strengthened to create awareness among potential mothers for seeking appropriate health care seeking from the beginning of pregnancy. Also, antenatal care follow-up can be emphasized for high-risk groups. A campaign for increased age at marriage and increased age at first birth should be launched to focus the health issues more extensively; and education for women needs to be given very high priority in order to bring about a lasting impact on the overall health condition of women.

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APPENDICES

Appendix 1: Human Research Ethical Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 De Sangber-Dery

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER M080969**
PROJECT	The Role of Birth Order in Infant Mortality in Ifakara in Tanzania
INVESTIGATORS	Mr M De Sangber-Dery
DEPARTMENT	School of Public Health
DATE CONSIDERED	08.09.26
DECISION OF THE COMMITTEE*	

Unless otherwise specified this ethical clearance is valid for 5 years and may be renewed upon application.

DATE **CHAIRPERSON** ....

(Professor P E Cleaton Jones)

*Guidelines for written 'informed consent' attached where applicable

cc: Supervisor : Prof KK Grobusch

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University.
I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to a completion of a yearly progress report.**

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

23/10/08

Appendix 2: Permission Letter to use IHDSS Data

IFAKARA HEALTH INSTITUTE
research | training | services

7 September 2008

Mr Matthew Dery Sangber-Dery
University of Wits
Public Health School
Johannesburg

Re: Permission and conditions to use selected DSS data

The Ifakara HDSS data is a sole property of the Ifakara Health Institute. Mr Matthew Dery Sangber-Dery, a student at the Wits University in SA is granted access to part of the Ifakara HDSS data within the collaboration of the University and IHI (formerly known as IHRDC-refer to the MOU). The data to be made available to Mr. Mathew Dery Sangber-Dery is strictly that contains the variables for the analysis of **"The Role of Birth Order in Infant Mortality in Rural Tanzania"** for years 2005-2007.

The following conditions have to be adhered to:

- Use of the data is strictly limited to the purpose of the mentioned study and only for the fulfillment of his academic requirements.
- The work is done under the supervision of IHI scientist, Dr Rose Nathan Lema
- All resulting publications will be co-authored and Ifakara will be clearly indicated as the institution that sourced the data

Dr Rose Nathan
For the Director, IHI

Appendix 3: Socio-economic status of household questionnaire

IC DSS – SOCIO ECONOMIC STATUS OF THE HOUSEHOLD 2008	
What is the head occupation? **(*Probe: mention=1, not mention=2*)**	
Peasant	|___|
Bulder	|___|
Small business	|___|
Business	|___|
Fisherman	|___|
Driver	|___|
Government employed	|___|
Other (mention) |___|___|___|___|__|___|___|___|___|___|___|___|___|___|___|___|___|___|__|	
Is it a rent household? (Yes=1, No=2)	|___|
The total number of sleeping room?	|___|___|
Number of sleeping room?	|___|
Does the household own any bednet? (Yes=1, No=2)	|___|
***If Yes,* what is the total number of bed nets?**	|___|___|
How many have been treated?	|___|___|
There is any bednets purchesed uisng voucher for pregnant women? (Yes=1, No=2)	|___|
There is any bednets purchesed using voucher for under five? (Yes=1, No=2)	|___|
How many people have slept in this household in last night?	|___|___|
How many slept under bednets in the last?	|___|___|
How many children under five slept in this household last night?	
How many children under five have slept under the bednets last night? *(Ask only if there is under five in the household)*	|___|___|

<table>
<tr><td colspan="2">In this household there is any one own.....</td></tr>
<tr><td>Bicycle (even not working one) (Yes=1, No=2)?</td><td>|___|</td></tr>
<tr><td>Radio (even not working one) (Yes=1, No=2)?</td><td>|___|</td></tr>
<tr><td>Mobile phone (even not working one) (Yes=1, No=2)?</td><td>|___|</td></tr>
<tr><td>Television((even not working one) (Yes=1, No=2)?</td><td>|___|</td></tr>
<tr><td>Motor cycle (even not working one) (Yes=1, No=2)?</td><td>|___|</td></tr>
<tr><td>Car (even not working one) (Yes=1, No=2)?</td><td>|___|</td></tr>
<tr><td>Milling machine (even not working one) (Yes=1, No=2)?</td><td>|___|</td></tr>
<tr><td>In this household do you keep animal? (1=Yes 2=No)</td><td>|___|___|</td></tr>
<tr><td>If Yes,</td><td></td></tr>
<tr><td>Number of cowsi?</td><td>|___|___|___|___|</td></tr>
<tr><td>Number of cawf?</td><td>|___|___|___|___|</td></tr>
<tr><td>Number of goats?</td><td>|___|___|___|___|</td></tr>
<tr><td>Number of sheep?</td><td>|___|___|___|___|</td></tr>
<tr><td>Number of chicken?</td><td>|___|___|___|___|</td></tr>
<tr><td>Number of dogs?</td><td>|___|___|___|___|</td></tr>
<tr><td>Number of cats?</td><td>|___|___|___|___|</td></tr>
<tr><td></td><td></td></tr>
<tr><td>There is any type of animal that not mentioned above? (1=Yes 2=No)</td><td>|____|</td></tr>
<tr><td colspan="2">If, Yes......................

Type Total

1____________________________ |___|____|____|___|___|___|

2____________________________ |___|____|____|___|___|___|

3____________________________ |___|____|____|___|___|___|

4____________________________ |___|____|____|___|___|___|</td></tr>
<tr><td>Connected to electricity (Yes=1, No=2)</td><td>|___|</td></tr>
<tr><td>House with iron roofi? (Yes=1, No=2)</td><td></td></tr>
</table>

(*if half roofed with roon, fill 1=Yes*)	|___|
Where are getting drinking water? **Tape=1, Deep well=2, Open well=3, River=4 Other=5 (mention)** **|___|___|___|___|___|___|___|___|____|____|____|____|____|____|____|____|___|**	|___|
How long it takes you to fetch water? Less than30=1, 30-60=2, More than one hour (Min60)=3	|___|
Toilet ? (Yes=1, No=2)	|___|
Checked by	|___|___|

Appendix 4: Pregnancy outcome questionnaire

01.05.2009 PREGOUT IC_DSS **Kuzaliwa/Matokeo ya Mimba**

Interviewer initial
|___|___|

Date of interview
|__|__|/|__|__|/|__|__|__|__|

Round number |___|___|

Bundle number
|___|____|

Information about mother:

Region
|___|___|___|

Location ID
|__|__|__|__|__|__|__|__|__|

Household number
|___|___|___|___|

Person number
|___|___|

Name
|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|

Perm ID
|__|__|__|__|__|__|__|__|__|__|__|__|__|

Date of event |__|__|/|__|__|/|__|__|__|__|

Who assisted during deliverly ? 1=Nurse/Doctor 2= TBA 3=Neighbour 4=No one 5=Other |___|

Other (mention) ____

Type of event[1] 1=Live brith, 2=Miscarriage, 3=Abortion
|___|

Child ever born
|__|__|

How many alive? |__|__|

When you was pregnant have you ever attended the ANCi?

Yes=1, No =2 |___|

How many visits have you made at ANC?
|__|__|

Place of deliverly?

Home=1, Hospital=2, Other pales=3 (mention)_________________________
|___|

If you the deliverly happened at health facility, after how many hours passed since deliverly to discharge?

Days |___|___| Hours|___|___|

If the deliverly happen at home, how takes to go to the health facilities since you have deliverly?

Days |___|___| Hours|___|___|

Is it twins (Yes=1, No =2) |__|

Number of twins? (Write total) |__|

If no write=88(N/A) |___|___|

If twin, all alive=1, One alive=2, All died=3 |___|

How do you deliverly? Normal=1 Operetion=2 |___|

Information about the child:

Region
|___|___|___|

Household number
|___|___|___|___|

[1] MH= Mtoto hai, MF= Still birth- ujauzito umetimiza umri wake wa kujifungua lakini amezaliwa mfu; MK= Ujauzito kuharibika au kutoka pasipo kutimiza umri wa kujifungua

Person number
|__|__|

Name
|___|___|___|___|___|___|___|___|____|____|___|__|____|___|___|___|___|

Sex (male=1,Fe=2)
|___|

Relation with the head of the household[2]
|__|__|

Father Id
|___|___|___|___|___|___|___|___|___|___|___|

Imekaguliwa na **|___|___|**

[2] **Uhusiano**: 1= Mtoto; 2=Kaka; 3= Dada; 4=Shemeji; 5= Mjukuu (GHD); 6= Shangazi/ mjomba/ binamu; 7= Mtu mwingine

Appendix 5: Dataset linkage

For the purpose of this study, variables selected from the datasets were:

MEMBER):== perm_id; birth_date; mother_id; sex; exit_date; exit_type; entry_type; entry_date

PREGNANCY):== mother_id; type of delivery; delivery assisted by; ANC; birth order; birth place; twins.

EDUCATION):== perm_id; birth date; edu2007; sex

There were three stages of data management:

Stage 1: To create attributes for a child from the Member dataset.

The DSS employed three entry types of its subjects:

- By birth
- By Enumeration during household registration, and
- By in-migration.

This study enrolled only children who entered the DSS study area by birth in the study period (2005 – 2007).

The main outcome variable of this study was whether a child born alive in the study period died before it reached its first birth day. For death of a child, the study enrolled only those who left the DSS site permanently by death.

Age_at_death of a child was calculated as:

(**exit_date** – **birth_date**)/365.25 years.

Dead=1, if the child left the DSS site permanently by death, and

Age_at_death<1yr (children who died before year 1)

Dead=0, if otherwise.

This dataset was sorted by mother_id and saved as ***Child.***

Stage 2: To create attributes for women from the Education dataset.

birth_date from this dataset was replaced with **mdob** (maternal date of birth) to distinguish it from that of the child.

Since the study was interested in Maternal Education as one of its explanatory variables, males were excluded from the dataset by deletion (when sex=male).

The **perm_id** in the maternal education dataset was replaced with **mother_id.**

The dataset was sorted by mother_id and saved as ***Mothers***

Stage 3: To create attributes for pregnant women from the Pregnancy dataset.

Here, the study considered pregnancy outcomes with live births, and with outcomes that occurred within the study period (2005 – 2007).

The following explanatory variables were extracted: type; assisted; ANC; birth_order; birth_place; twins.

The data was sorted by mother_id and saved as ***Pregwomen***.

- **Merging datasets**

For a complete dataset for analysis, the ***Pregwomen*** data was merged with the ***Mothers*** data using **mother_id** and sorted by mother_id.

It was saved as ***Women.***

The ***Women*** data was in turn merged with the ***Child*** data and finally saved as ***ForAnalysis.***

In analysis involving unique household identification number, Stata command below is used:

```
encode region,gen(vilno)

gen houseid=vilno*100000+family_num
```

where `‘houseid’` is the unique household identification number generated

`‘vilno’` is the village attribute

`‘100000’` is a multiplier; and

`‘family_num’` is the family member identification number.

The dataset ‘**ForAnalysis’** was finally merged with the socio-economic status data using the household identification number.

Appendix 6: Percentage distribution of live births by place of delivery

Variable	Place of Delivery (N, %)		
	Health Facility	***Home***	***Total***
Birth Order			
1	1183 (22)	496 (14)	
2-5	3324 (62)	2323 (65)	
6+	835 (16)	755 (21)	**8916 (100)**
Sex			
Female	2551 (48)	1813 (51)	
Male	2791 (52)	1761 (49)	**8916 (100)**
Maternal age (yrs)			
<20	1027 (19)	524 (15)	
20 – 34	3585 (67)	2468 (69)	
35+	730 (14)	582 (16)	**8916 (100)**
Twin birth			
Yes	199 (4)	124 (3)	
No	5142 (96)	3447 (97)	**8912 (100)**
Antenatal Care (ANC)			
Yes	4507 (98)	3045 (98)	
No	78 (2)	50 (2)	**7680 (100)**
Maternal education			
Beyond primary	115 (2)	53 (1)	
Complete primary	3132 (59)	1974 (55)	
Incomplete primary	1302 (24)	911 (25)	
No formal education	793 (15)	636 (18)	**8916 (100)**

Variable	Place of Delivery (N, %)		
	Health Facility	***Home***	***Total***
Delivery assistance			
*Doctor/nurse**	3300 (62)	2212 (61)	
TBA	1321 (25)	860 (24)	
Neighbour	247 (5)	169 (5)	
No one	114 (2)	91 (3)	
Other	360 (7)	242 (7)	**8916 (100)**
Household Head Occupation			
Employed (salary)	105 (2)	87 (2)	
Farmer	4294 (80)	2906 (81)	
Fisherman	200 (4)	133 (4)	
Business	665 (13)	375 (11)	
Driver	9 (0)	12 (0)	
Mason	69 (1)	61 (2)	**8916 (100)**
Wealth index			
Least poor	810 (15)	687 (19)	
Less poor	990 (19)	738 (21)	
Poor	1210 (23)	824 (23)	
Poorer	1122 (21)	730 (20)	
Poorest	1210 (22)	595 (17)	**8916 (100)**

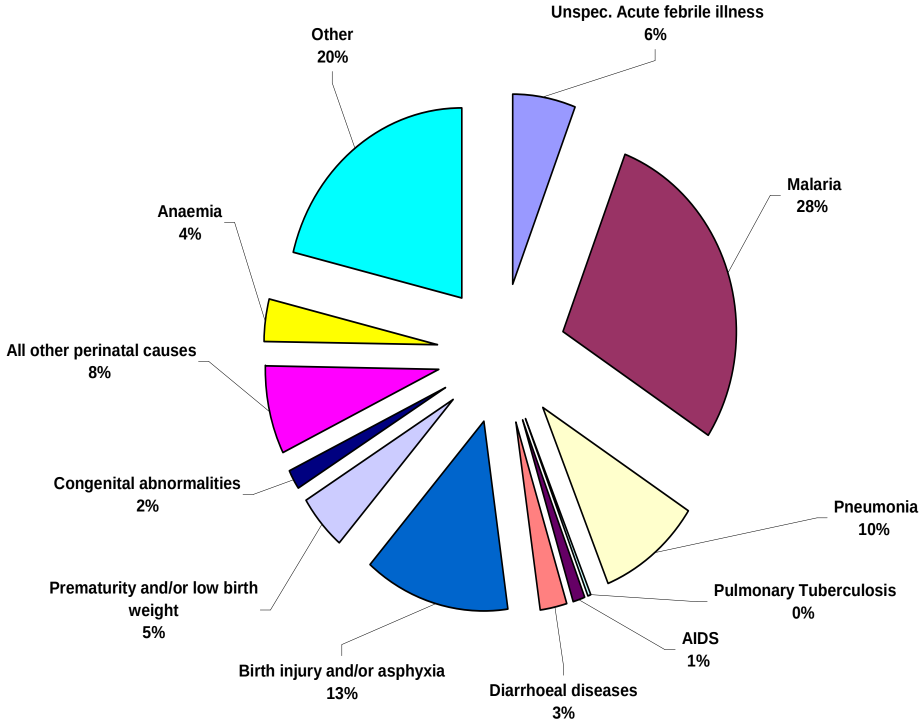
* includes clinicians

Appendix 7: Percentage distribution of live births by delivery assistance

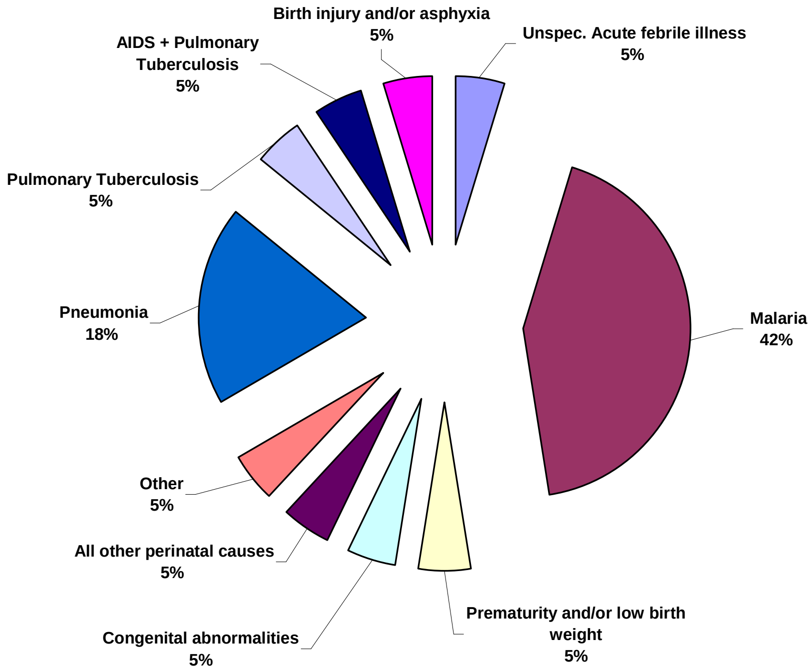
Variable	Delivery Assistance (%)				
	Doctor/Nurse	***TBA***	***Neighbour***	***None***	***Other***
Sex					
Female	2695 (49)	1050 (48)	210 (51)	113 (55)	296 (49)
Male	2817 (51)	1131 (52)	206 (49)	92 (45)	306 (51)
Maternal age (yrs)					
<20	971 (18)	377 (17)	77 (19)	35 (17)	91 (15)
20 – 34	3724 (68)	1483 (68)	297 (71)	134 (65)	415(69)
35+	817 (14)	321 (15)	42 (10)	36 (18)	96 (16)
Twin birth					
Yes	220 (4)	69 (3)	8 (2)	9 (4)	17 (3)
No	5289 (96)	2111 (97)	408 (98)	196 (96)	585 (97)
Antenatal Care (ANC)					
Yes	4765(98)	1821(99)	344 (97)	170 (98)	452 (98)
No	86 (2)	20 (1)	10 (3)	4 (2)	8 (2)
Maternal education					
Beyond primary	102 (2)	39 (2)	9 (2)	4 (2)	14 (2)
Complete primary	3149 (57)	246 (57)	236 (57)	131 (64)	344 (57)
Incomplete primary	1355 (25)	543 (25)	118 (28)	40 (20)	157 (26)
No formal education	906 (16)	353 (16)	53 (13)	30 (14)	87 (15)

Variable	Delivery Assistance (%)				
	Doctor/Nurse	***TBA***	***Neighbour***	***None***	***Other***
Household Head Occupation					
Employed (salary)	123 (2)	36 (2)	11 (3)	5 (2)	17 (3)
Farmer	4440 (81)	1777 (82)	333 (80)	167 (81)	483 (80)
Fisherman	215 (4)	69 (3)	12 (3)	8 (4)	29 (5)
Business	643 (12)	260 (11)	52 (12)	22 (11)	63 (10)
Driver	12 (0)	4 (0)	2 (1)	0 (0)	3 (1)
Mason	79 (1)	35 (2)	6 (1)	3 (2)	7 (1)
Wealth index					
Least poor	923 (17)	383 (18)	63 (15)	32 (16)	96 (16)
Less poor	1080 (20)	418 (19)	88 (21)	30 (15)	112 (19)
Poor	1248 (22)	506 (23)	91(22)	52 (25)	137 (23)
Poorer	1153 (21)	434 (20)	83 (20)	49 (24)	133 (22)
Poorest	1108 (20)	440 (20)	91(22)	42 (20)	124 (20)

Appendix 8: Causes of infant death in 2005, IHDSS



Appendix 9: Causes of infant death in 2006, IHDSS



Appendix 10: Causes of infant death in 2007, IHDSS